An Event-related Brain Potential Study of English Morphosyntactic Processing in Japanese Learners of English

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by

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To Mizuki and Yuzuki

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Abstract

This dissertation investigated the neural mechanisms underlying English morphosyntactic processing in Case, subject-verb agreement, and past tense inflection in Japanese learners of English (JLEs) using event-related brain potentials (ERPs) in terms of the effects of the age of second language (L2) acquisition (the age of learning English), L2 proficiency level (the English proficiency level), and native/first language (L1) transfer.

Researchers have debated for a number of years the question of whether there is access to Universal Grammar (UG) in L2 acquisition (White, 1989) as it is argued by Chomsky (1957) (as well as many others) that children have full access to UG in L1 acquisition. Although researchers have agreed to the accessibility in L2 acquisition to some extent, they have had different perspectives for the well-known phenomenon; L2 learners use verbal and nominal inflections variably or optionally under circumstances in which native speakers obligatorily use inflectional morphology. This dissertation evaluates two perspectives to account for L2 learners' morphological variability: the Missing Surface Inflection Hypothesis (MSIH) (Prévost & White, 2000) predicts that L2 learners' morphological variability is not a competence problem but rather *a performance problem* connecting the phonological forms with syntactic representations in speech production; and the Representational Deficit Hypothesis (RDH) (Tsimpli, 2003) predicts that L2 learners' morphological variability is due to *a permanent deficiency at the computational level* in acquiring uninterpretable features (not present in the L1) rather than due to performance errors.

English morphological variability by JLEs has been examined mostly by behavioral methods, and only a few studies have employed neurophysiological methods such as ERPs to investigate the neuronal mechanisms underlying the variability by JLEs. That is one of the most critical reasons why the present study employed ERPs. ERPs are

one of the most advanced and reliable neurophysiological techniques to explore cognitive processes in the brain, and refer to scalp-recorded brain potentials that respond to external stimulation by various modalities such as visual or auditory, or to internal processes triggered by the stimulation. Using the ERP technique, it is possible to minimalize performance errors and investigate the physiological and psychological status of cognitive processing for linguistic stimuli owing to its data with a high-temporal resolution. Thus, the present study employed ERPs to investigate L2 learners' sensitivity to L2 morphosyntactic violations and the underlying neural mechanisms associated with their sensitivity.

In the experiment, in order to assess the effects of the age of L2 acquisition and L2 proficiency level, JLEs were divided into four groups according to the age of learning English (*Early* or *Late*) and their English proficiency level (*High* or *Low*). The materials, which were visually presented word by word in the center of a computer screen, consisted of English stimuli for the following three conditions in order to assess the effect of L1 transfer: *Case*, *Present* (subject-verb agreement), and *Past* (past tense inflection). All of the conditions show the linguistic differences in the morphological representation system between English and Japanese (*the operation of Agree* in English, *no Agree*/*morphological merge*r in Japanese).

The ERP results in a group of English native speakers (ENS) showed a similar ERP pattern, which represented a typical pattern for morphosyntactic processing, namely an early negativity which is followed by P600 across the three conditions, whereas those in the JLE groups were qualitatively or quantitatively different from those in the ENS group and among the JLE groups according to the conditions. Among the three effects (the age of L2 acquisition, L2 proficiency level, and L1 transfer), the effect of the English proficiency level, which was apparent for the Present condition, on the processing of subject-verb agreement in English was most clear in both the behavioral and ERP results. P600 was present in the ENS and High groups, and no ERP component was present in the Low groups. This successful acquisition and processing have been constrained by L1 transfer of the morphological representation system because the system (the operation of Agree) does not present in Japanese. The effect of the age of learning English was observed for the Past condition: An early negativity was observed in the Early groups, while more sustained negativity, which reflects working memory, was observed in the Late groups. Because of the observation of the native-like brain activities shown in the ERP results in the High groups for the conditions which show the linguistic differences in the morphological representation system between English and Japanese, we suggested that L2 learners' grammar was constrained by UG. Accordingly, the present study supported the full access to the UG position, and no evidence was found to support the RDH.

In conclusion, the findings suggested that JLEs were able to acquire and process the operation of Agree in English, and the English proficiency level and L1 transfer of the morphological representation system could have effects on English morphosyntactic processing in JLEs. In addition, the present study suggested that the general cognitive function associated with working memory seemed to be more predominantly involved than L2 morphosyntactic processing in a certain aspect of L2 processing. This cognitive function of working memory could belong to a third factor which, Chomsky (2007) insists, is one of the factors involved in the development of language along with UG and external data from the view point of evolutional biology.

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Chapter 1
Introduction

1.1 Preface

The present study aims to investigate the neural mechanisms underlying English morphosyntactic processing in Japanese learners of English (JLEs) using event-related brain potentials (ERPs).

One of the most important questions in research on second language[1] (L2) acquisition is "why L2 learners make errors." Among various factors that might affect the errors by L2 learners, the age of L2 acquisition, L2 proficiency level, and native/first language[2] (L1) transfer have been prominently focused on and discussed in the hypotheses and studies of L2 acquisition.

Seeking possible answers to the questions above, the present study examines the neural mechanisms underlying English morphosyntactic processing in Case, subject-verb agreement, and past tense inflection in JLEs in terms of the three effects from the viewpoint of neurophysiology of L2 acquisition.

Language acquisition and processing have been traditionally investigated with production data and behavioral methods such as grammaticality judgment and reaction time tasks. Since the 1980s the neurophysiological techniques such as ERPs and functional Magnetic Resonance Imaging (fMRI) have been employed for investigating language acquisition and processing. ERPs refer to small changes of scalp-recorded voltage triggered by external or internal stimulation, and provide us very precise temporal information reflecting the brain activities in a short period. The new techniques such as ERPs and fMRI have shed light on the investigation of neural activity in the brain directly or indirectly during language processing. The data obtained

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[1] A language that is not a native language in a country or acquired after the acquisition of one's native language (Richards, Platt, & Weber, 1985).
[2] A person's mother tongue or the language acquired first (Richards, Platt, & Weber, 1985).

by the techniques are informative in that they show us the physiological and psychological status of cognitive process for linguistic stimuli, detecting small quantitative and qualitative differences in the time course and in the degree of neural activity during language processing between native speakers and L2 learners, and also among L2 learners grouped by certain criteria.

This empirical study based on linguistic theory will be expected to be a very fruitful and productive endeavor in providing a deeper understanding of the mechanisms specific to L2 and foreign language acquisition and processing as well as a biological endowment for language.

1.2 Organization of the Dissertation

The rest of chapter 1 represents the theoretical background of the dissertation, that is, the theory of Universal Grammar (UG). Along with the historical development from the theory of Generative Grammar (GG) (Chomsky, 1957) to the Minimalist Program (MP) (Chomsky, 1995), the shift of focus on a Faculty of Language (FL) and UG is described below.

Chapter 2 introduces competing hypotheses of L2 acquisition within the framework of the MP, and critically evaluates studies of L2 acquisition associated with two perspectives to account for L2 learners' morphological variability: the Missing Surface Inflection Hypothesis (MSIH) (Prévost & White, 2000) predicts that L2 learners' morphological variability is not a competence problem but rather a *performance problem* connecting the phonological forms with syntactic representations in speech production; and the Representational Deficit Hypothesis (RDH) (Tsimpli, 2003) predicts that L2 learners' morphological variability is due to *a permanent deficiency at the computational level* in acquiring uninterpretable features (not present in the L1) rather than due to performance errors.

Chapter 3 reviews studies of language processing using neurophysiological methods, mainly using ERPs. Giving an outline of ERPs, ERP studies of language processing in native speakers and monolinguals[3] are reviewed first, and then those of L2 processing in bilinguals and L2 learners are systematically reviewed in terms of the effects of the age of L2 acquisition, L2 proficiency level, and L1 transfer. After that, developmental stages of L2 morphosyntactic processing in late L2 learners as indexed by ERP components are introduced. In addition to ERP studies, some fMRI studies of L2 processing in bilinguals and L2 learners are reviewed.

Chapter 4 presents the experiment using ERPs. In order to assess the effects of the age of L2 acquisition and L2 proficiency level, JLEs were divided into four groups according to their age of learning English (*Early* or *Late*) and English proficiency level (*High* or *Low*): Early-High (EH), Early-Low (EL), Late-High (LH), and Late-Low (LL). The materials, which were visually presented word by word in the center of a computer screen, consisted of English stimuli for the following three conditions in order to assess the effect of L1 transfer: *Case*, *Present* (subject-verb agreement), and *Past* (past tense inflection). All of the conditions show the linguistic differences in the morphological representation system between English and Japanese.

Chapter 5 reports the behavioral and ERP results for each condition. The ERP results in a group of English native speakers (ENS) showed a similar ERP pattern, which represented a typical pattern for morphosyntactic processing, namely an early negativity followed by P600 across the three conditions, whereas those in the JLE groups were qualitatively or quantitatively different from those in the ENS group and among the JLE groups according to the conditions.

Chapter 6 reviews the ERP results and provides the interpretations and discussions comprehensively across the three conditions. It is suggested that JLEs are able to acquire and process uninterpretable features of functional categories in English,

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[3] A person who knows and uses only one language (Richards, Platt, & Weber, 1985).

and English morphosyntactic processing in JLEs is affected by the English proficiency level and L1 transfer of the morphological representation system. In addition, the present study suggested that the general cognitive function associated with working memory seemed to be more predominantly involved than L2 morphosyntactic processing in a certain aspect of L2 processing, which could be affected by the age of learning English. Accordingly, the results support the full access to UG position, showing no evidence to support the RDH.

The last chapter summarizes the previous chapters, and makes some concluding remarks on English morphosyntactic processing in JLEs.

1.3 Generative Grammar

If children grow up under normal conditions without any neurological and psychological disorders, before the age of five, they are able to uniformly and rapidly produce and interpret sentences that they have never encountered without having had any formal instruction. This extraordinary ability of acquiring language leads us to *Plato's Problem*, which presents the question of how we can account for our tacit linguistic knowledge even though substantive input from the environment seems to be insufficient. The gap between what we know and the apparent lack of direct evidence from the linguistic environment in language acquisition has been explained by postulating a *Faculty of Language* (FL). The FL is an innate language-specific endowment which is supposed to be in the mind/brain of human beings. According to *Generative Grammar* (GG) (Chomsky, 1957), the FL incorporates a theory of *Universal Grammar* (UG), which is characterized as the initial state in the FL in language acquisition (Chomsky, 1981). Hence the ultimate goal in exploring the nature of FL is to formulate the theory of UG.

The term Generative Grammar denotes the system of rules, in particular rules of syntax, which characterize sentences as either well-formed or not, in other words, as either possible as natural human languages or not. In Chomsky's view, the properties of the GG are not only simply the results of learning from the environment, but also arise from the innate language faculty consisting of *grammar*, which is *universal* to all possible human languages, called *UG*. Hence it follows that owing to UG, children are able to induce the complex operations of any human languages under circumstances in which the *stimulus* they have had exhibits *poverty* in the sense that they have had only partial exposure to the limited linguistic data, called the Primary Linguistic Data (PLD). This is referred to as the *poverty of the stimulus* in language acquisition. Considerations of UG and the poverty of the stimulus support the view that English native speakers intuitively figure out that the sentence *Colorless green ideas sleep furiously* is grammatical but meaningless, although the sentence has never been spoken before.

A core aspect of the early GG is a distinction between two different representations of a sentence, called Deep Structure (D-Structure) and Surface Structure (S-Structure). The organization of grammar in the standard theory of GG (Chomsky, 1965) can be schematized as Figure 1.1.

Deep Structure → Semantic component

Transformations

Surface Structure → Phonetic Form

Figure 1.1. The organization of grammar in the standard theory of Generative Grammar.

The two representations are linked to each other via transformations such as *wh*-movement transformation and passive transformation, that is, via syntactic mapping. D-Structure represents the core semantic relations of a sentence. That is, it projects theta

(θ) roles (i.e., the semantic roles played by arguments in relation to their predicates) of lexical items: Anything interpreted as the subject or object of a given sentence is in the subject or object position of the sentence at D-structure no matter where it generates at S-structure. S-Structure, on the other hand, represents the Phonetic Form (PF) of the sentence.

Since the Revised Extended Theory of GG (Chomsky, 1973), the semantic component had been assumed to be connected to S-Structure instead of D-Structure, and the operations of the transformation are unified under the name of *Move α*. *Move α* in practice means that "move any constituents anywhere in a sentence," and refers to the relationship between an indexed constituent and its trace *t* (e.g., the relationship between What_i and t_i in "What_i do you think that Mary fixed t_i?").

1.4 The Government and Binding Theory

As Chomsky (1981) had developed the linguistic theory from the GG into the Government and Binding (GB) theory, in order to explore the nature of FL, it is not enough for the theory of UG simply to list the sets of properties of human language as the earlier theory had tried to do. Then, with the development of the linguistic theory, the main focus of the theory had shifted from the formulation of rule systems in a particular human language into that of a system of principles of UG. Correspondingly, adequacy for evaluating the linguistic theory had also shifted from *descriptive adequacy*, which accounts for the phenomena of a particular human language into *explanatory adequacy,* which explains the initial and steady states of FL in language acquisition.

The GB theory has two central subtheories as the name suggests: *Government* deals with "the relations between the head of a construction and categories dependent on it" (Chomsky, 1981, p. 6). *Binding*, on the other hand, deals with "the relations of anaphors, pronouns, names and variables to possible antecedents" (ibid, p. 6). In the GB theory, Logical Form (LF) is introduced between S-Structure and the semantic component in order to specify aspects of the meaning of a sentence. The organization of grammar in the GB theory can be schematized as Figure 1.2.

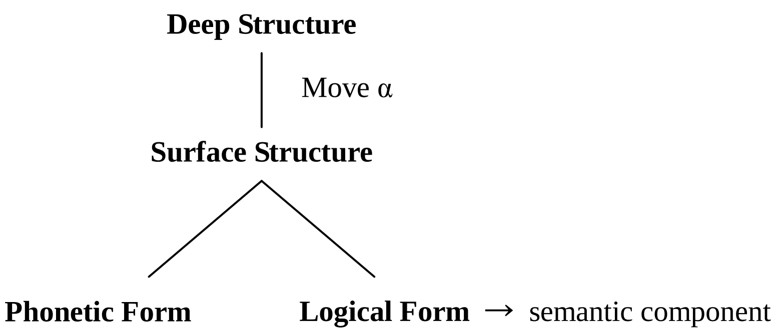


Figure 1.2. The organization of grammar in the Government and Binding Theory.

The GB theory is known as the Principles-and-Parameters (henceforth, P&P) approach because it postulates that UG consists of principles and parameters. The central idea of the P&P approach is that syntactic knowledge of human beings can be modeled with principles, which are common to all human languages, and parameters, which determine syntactic variability among languages by setting the binary values. The P&P approach assumes that language acquisition involves two types of learning: lexical learning, which involves acquiring the words to be stored in the mental lexicon of a language; and grammatical learning, which involves acquiring the syntax of a language. Ideally, grammatical learning does not require children to learn all grammars in a language, but limits them to set the parameter values by binary choices. Consequently, language acquisition relies on the lexical learning and the parameter setting specific to the language children acquire. It means in turn that the differences among languages can be parametric variations.

One of the parametric variations among languages is shown in *wh*-questions in (1), in which (1a) is in English and (1b) is its Japanese counterpart.

(1) a. Who did you say would do what?

b. Anata-wa dare-ga nani-wo su-ru to iimashi-ta ka?

(you-TOP who-NOM what-ACC would do that say-past Q?)

Focusing on *wh*-expressions in (1), the first *wh*-expression *who*, which was originally generated immediately before *would* as a subject of the embedded sentence, is moved to the front of the sentence in (1a), whereas neither the first *wh*-expression *dare* nor the second *wh*-expression *nani* is moved to the front of the sentence, in other words, they remain *in situ* in (1b). In case of (1), one of the parametric variations between English and Japanese can be explained by a parameter called the *wh*-parameter, which determines whether or not *wh*-expressions must be moved to the front of interrogative sentences containing them, that is, to [Spec, CP] (the Specifier[4] position of a complementizer phrase).

In case of (1), one of the related principles incorporated in UG is the Locality Principle. The Locality Principle requires any grammatical operation to be performed within a specific local domain in reference to the movement of the first *wh*-expression *who* to the front of the sentence and the first auxiliary *did* to the front of the subject *you* in (1a). As a consequence of the Locality Principle, the first *wh*-expression *who* and the first auxiliary *did*, which are the most local, in other words, the closest to the front of the sentence, are fronted in (1a). Neither the second *wh*-expression *what* nor the second auxiliary *would* can be fronted because they are not the closest to the front of the sentence, or moving *what* to the front of the sentence and/or *would* to the front of the subject *you* results in an ungrammatical sentence. Because the Locality Principle is one of the principles in UG, all grammatical operations in all human languages are subject to the principle.

Accordingly, principles such as the Locality Principle capture the nature of

[4] A type of constituent which adjoins a head and its complement (an intermediate projection) to form a maximal project.

language with universality, whereas parameters accompanied with the principles such as the *wh*-parameter capture the relativity and the diversity of any possible human language.

1.5 The Minimalist Program

As the earlier work in linguistic theory had postulated many rules and principles, in recent work by Chomsky (1995), the Minimalist Program (MP) has postulated that UG involves only a *Computational System of human language* (C_{HL}) and *Lexicon*. The organization of the language faculty in the MP can be schematized as Figure 1.3.

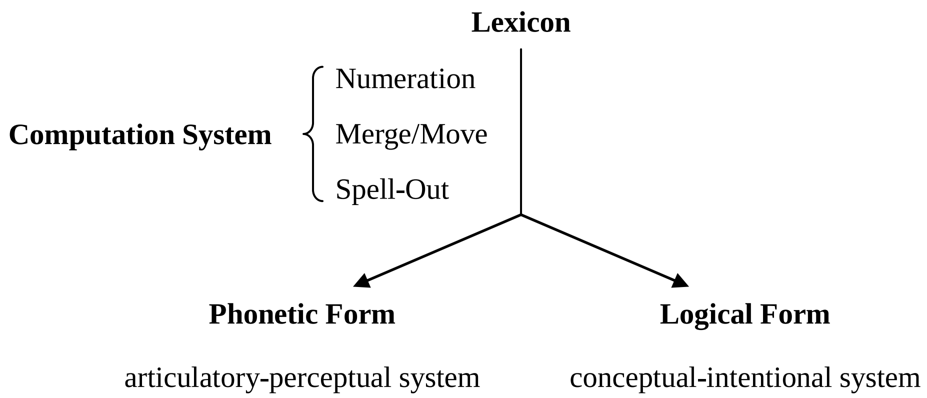


Figure 1.3. The organization of the language faculty in the Minimalist Program.

The MP suggests that UG is realized by a perfect system under the spirit of optimality in the sense that it contains perfectly only the requirements for articulatory-perceptual (A-P) system, which is responsible for producing and listening of the information and conceptual-intentional (C-I) system, which is responsible for understanding of the information. Accordingly, the MP refers to a program which has attempted to formulate a grammar with the minimal number of theoretical constructs and operations for a derivation, which satisfies economy conditions.

1.5.1 Computation System

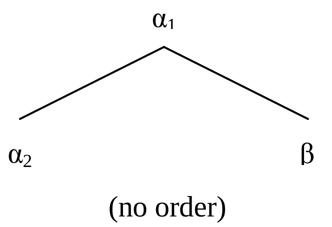
The C_{HL} is assumed to be universally invariant and consists of computational and phonological components. The computational component involves the mechanisms for combining or moving symbols in particular ways, the operations known as *Merge* and *Move*. The properties of the two operations are explained below in this section.

Chomsky (1995) states that "the computational system C_{HL} is strictly derivational" (p. 224). As shown in Figure 1.3, the first stage of building a linguistic expression is to *select* lexical items from the lexicon, and the list of the selected items is called *numeration*. Next, the operations *Merge* and *Move* are applied to the items selected from the numeration. Then the phonetic information of the syntactic objects is sent to PF at a certain point of the derivation; this is called *Spell-Out*. PF is considered to be an interface with the A-P system. The other information, namely semantic information is sent to LF, which is in turn considered to be an interface with the C-I system. The information derived at LF must be inclusive in the numeration (Inclusiveness Condition). There are no levels of D-Structure or S-Structure, which is postulated in the GB, and PF and LF must consist of legitimate constituents which are interpretable at the A-P system and the C-I system, respectively (Principle of Full Interpretation).

1.5.1.1 Merge

The operation *Merge* creates a pair of syntactic objects with those already built and constructs them into a new syntactic object. This can be represented as $K = \{\gamma, \{\alpha, \beta\}\}$, in which γ is the label of the syntactic object K, and α and β are the constituents of K. Because Merge is asymmetric, either α or β projects as the head of K: If α projects, then α is called target and the projection forms $K = \{\alpha_1, \{\alpha_2, \beta\}\}$ as shown in (2).

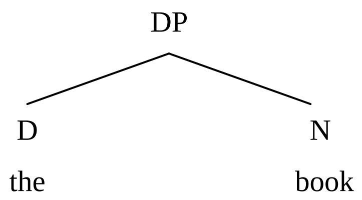
(2)



(Chomsky, 1995: 245)

An example of Merge is shown in (3), in which the determiner phrase (DP) *the book* is formed by merging the determiner (D) *the* with the noun (N) *book*.

(3)

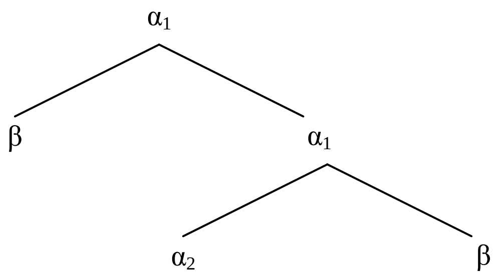


Chomsky (2001) distinguishes between external and internal Merge. External Merge, as described above, adjoins two separate syntactic objects to form a new syntactic object. Internal Merge refers to Move as described below.

1.5.1.2 Move

The operation *Move* substitutes an element from syntactic objects and adjoins it in order to form two segment categories. This can be represented as L = {H(K), {α, K}}, in which H(K) is the label of the projected element K. In consequence of the substitution and adjunction, Move forms the chain CH = (α, *t*(α)), in which *t*(α) is the trace of α. For example, suppose that the object (2) is constructed, and then (4) is constructed by raising β, and targeting and projecting α_1.

(4)



The chain meets the C-Command Condition in (5) and Chain Uniformity Condition in (6)[5] among others.

(5) C-Command Condition

α must c-command its trace.

(Chomsky, 1995: 253)

(6) Chain Uniformity Condition

A chain is uniform with regard to phrase structure status.

(Chomsky, 1995: 253)

1.5.2 Lexicon

The lexicon deals with an inventory of features including phonetic, semantic, and formal features, and consists of lexical and functional categories. The lexical categories include noun (N), verb (V), preposition (P), adjective (A), adverb (ADV), and do not carry formal features. The functional categories[6], on the other hand, include determiner (D), complementizer (C), pronouns (PRN), tense-maker (T), Agreement (Agr)[7], and light verb (*v*), taking part in computation, and, in contrast to lexical categories, carry

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[5] The *phrase structure status* of an element refers to "its (relational) property of being maximal, minimal, or neither" (Chomsky, 2005: 253).

[6] Chomsky (2000) calls C (expressing force/mood), T (tense/event structure), and *v* (the "light verb" head of transitive constructions) core functional categories.

[7] Agr is present only for theory-internal reasons, and it consists of interpretable formal features only unlike other functional categories (Chomsky, 1995).

formal features.

Formal features are divided into interpretable and uninterpretable features. Interpretable features are relevant for LF interpretation and are used to interpret the components, including categorical features ([nominal]/[verbal]), phi (φ)-features of nominals ([number]/[person]/[gender]), and tense feature of Vs ([present]/[past]). On the contrary, uninterpretable features are not interpreted at LF, and therefore must be checked and then deleted by interpretable features under c-command[8] relations. The interpretable features include Case features of nominals and Vs ([nominative]/[accusative]/[genitive]), φ-features of Vs ([number]/[person]/[gender]), and inflectional feature of *v* ([Infl][9]).

Uninterpretable features are subdivided into strong and weak features. Strong features must be deleted before Spell-Out and triggers overt movement, whereas weak features are deleted at LF and triggers covert movement. Chomsky (2000) introduced an operation *Agree,* and thereafter the notion of feature strength was not used for explanation of movement.

Under the MP, parametric variations among languages are assumed to be associated with the properties of functional categories. That is, languages could vary in the representations at the level of a particular functional category, that of formal features of a particular functional category, or that of feature strength. For example, it is supposed that Japanese lacks φ-features (Fukui & Sakai, 2003), and the inflection (I = T in more recent work) feature is strong, for example, in French but weak in English (Pollock, 1989). Therefore, careful investigation of the state of functional categories in language learners is a critical element for research on language acquisition and processing. Especially in research on L2 acquisition and processing, the state of formal features (uninterpretable features) of functional categories has been investigated. These

[8] A c-commands node B iff the branching node most immediately dominating A also dominates B (Chomsky, 1986b, p. 8).

[9] The dissertation uses the notation [Infl], which represents [*u*Infl:] for uninterpretable inflectional feature in Adger (2003). *u* represents an unvalued inflectional feature, which is equivalent to an uninterpretable feature.

studies in turn would take charge of the exploration of the nature of FL. These will be discussed in detail in the next chapter.

1.5.3 Agree

Features play an important role in the course of a derivation, and as Chomsky (1995) says, "[a] core property of the C_{HL} is feature checking." The operation by which uninterpretable features are checked and then deleted by interpretable features under c-command relations is called *agreement*. Baker (2008) adapts the theory of *Agree* developed by Chomsky (2000) and puts the syntactic conditions on *Agree* together as follows:

> A functional head F agrees with XP, XP a maximal projection only if:
>
> a. F c-commands XP or XP co-commands F (the c-command condition).
>
> b. There is no YP such that YP comes between XP and F and YP has φ-features (the intervention condition).
>
> c. XP is made active for agreement by having an unchecked case feature (the activity condition).
>
> (Baker, 2008: 48)

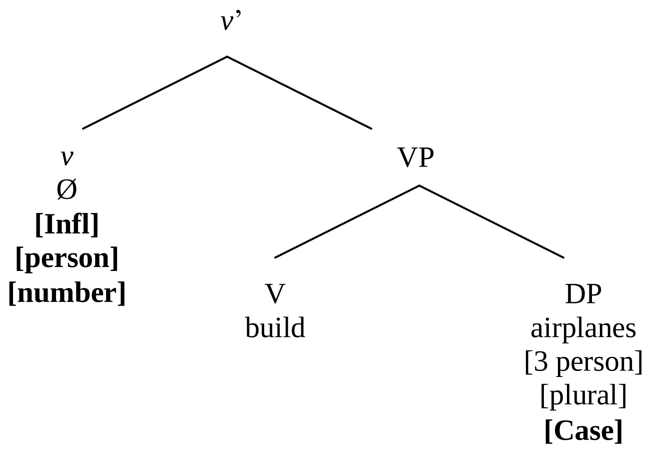
We analyzed the operation of *Agree* by derivation of a sentence *We build airplanes*[10].

After numeration, DP *airplanes* ($[_{DP}$ $[_{D}$ Ø$][_{NP}$ airplanes$]]$) with interpretable φ-features [3 person] [plural] and the uninterpretable Case feature [Case] merges with V *build* to form VP, and the VP in turn merges with a null transitive *v Ø* with the uninterpretable inflectional feature [Infl] and uninterpretable φ-features [person][number], forming *v*' as shown in (7), in which uninterpretable features are in

[10] This analysis follows Adger (2003).

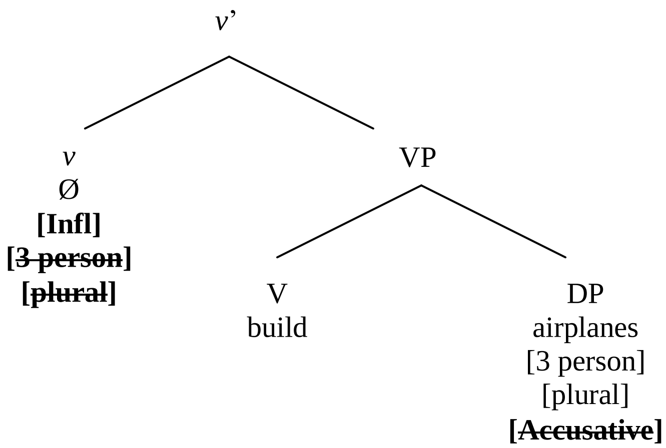
bold.

(7)



The uninterpretable φ-features [person][number] of *v Ø* are checked by the interpretable φ-features [3 person][plural] of DP *airplanes* as a consequence of Agree. Conversely, the uninterpretable Case feature [Case] of DP *airplanes* is checked and valued as accusative by the *v Ø*. Once uninterpretable features are checked, they must be deleted as ~~strikeout~~ in (8) indicates, or the derivation crashes, in other words, yields an illegitimate linguistic expression because uninterpretable features remain and they are illegible at LF.

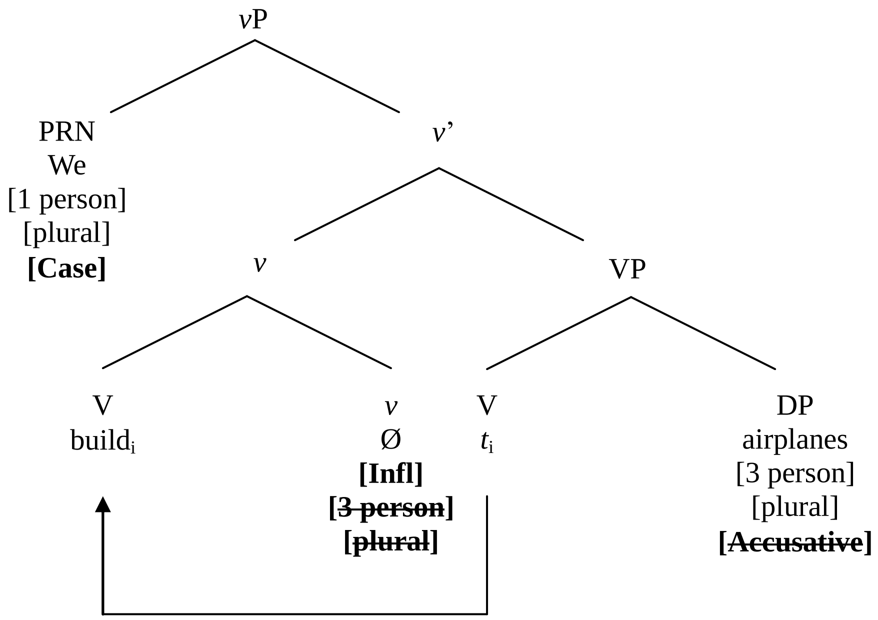
(8)



Due to being an affix in nature, the *v Ø* triggers raising the V *build* from within

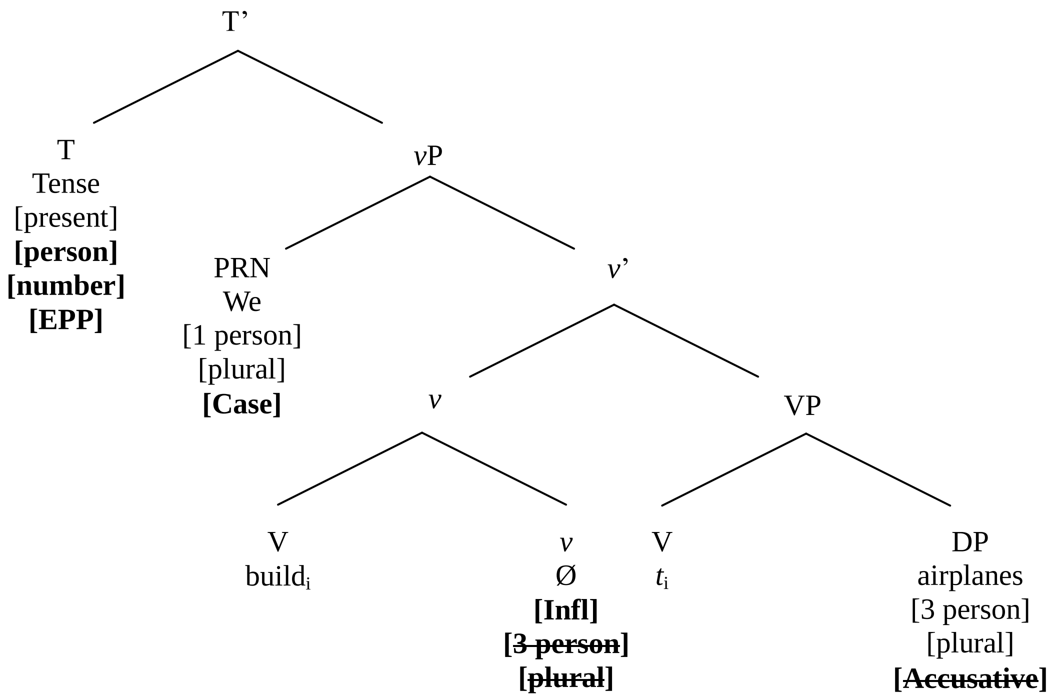
VP to *v* as indicated in (9). In addition, the *v* Ø projects an external argument by merging PRN *We* with interpretable φ-features [1 person] [plural] and the uninterpretable Case feature [Case], forming *v*P as shown in (9).

(9)



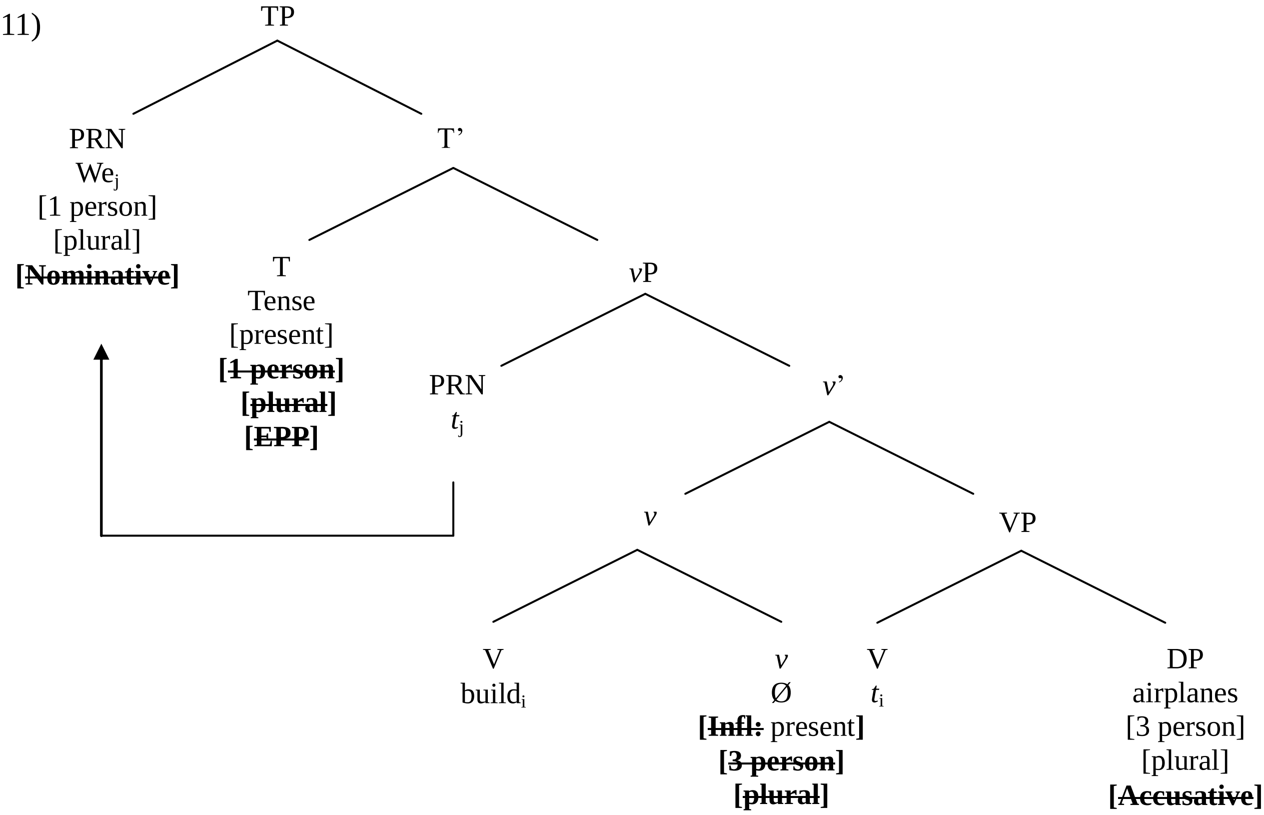
For the next step, the *v*P merges with the finite T with interpretable tense feature [present], uninterpretable φ-features [person][number], and the uninterpretable [EPP] (EPP = Extended Projection Principle) feature, forming T’ as shown in (10).

(10)



Because the [EPP] feature requires T to have an extended projection into TP with a subject, the [EPP] feature triggers the movement of PRN *We* from [Spec, *v*P] to [Spec, TP] as indicated in (11). Thereby the uninterpretable [EPP] feature is deleted, and also the uninterpretable φ-features [person][number] of T are checked and then deleted by the interpretable φ-features [person][number] of PRN *We*. The uninterpretable Case feature [Case] of PRN *We* in turn is checked and valued as nominative by the T, and then is deleted. For subject-verb agreement, the interpretable tense feature [present] of T values the uninterpretable inflectional feature [Infl] of *v* as [present]. Accordingly, subject-verb agreement is represented with a *Ø* morpheme attached to the end of the V *build* for the 1st-person plural-number subject PRN *We* as a consequence of Agree between the interpretable tense feature [present] of T and the uninterpretable inflectional feature [Infl] of *v*. These sequential procedures of Agree are shown in (11).

(11)



Finally, the TP merges with a null declarative C *Ø*, resulting in terminating the derivation CP *Ø We build airplanes*, which has all of the uninterpretable features checked and deleted.

It is noteworthy that interpretable features are crucial for semantic representation, whereas uninterpretable features are crucial in a course of a derivation because the features trigger the operation of Agree. Whether or not acquisition of these uninterpretable features responsible for the morphological representations is problematic for L2 learners is debatable. These will be described in the next chapter in detail.

1.5.4 Universal Grammar as a Mental Organ

As UG is regarded as a mental organ, it is believed to be one of the three factors involved in the development of language from the viewpoint of evolutional biology in more recent work by Chomsky (2007). As Chomsky puts it;

> Evidently, development of language in the individual must involve three factors: (1) genetic endowment, which sets limits on the attainable languages, thereby making language acquisition possible; (2) external data, converted to the experience that selects one or another language within a narrow range; (3) principles not specific to FL. Some of the third factor principles have the flavor of the constraints that enter into all facets of growth and evolution, and that are now being explored intensively in the evo-devo revolution. (Chomsky, 2007: 3)

The first factor (1) refers to UG, and the second factor (2) is the linguistic data that children are exposed to. Then, the third factor (3) refers to the general properties independent of UG and external data, such as memory, respiration, digestion, circulation (Hauser, Chomsky, & Fitch, 2002, pp. 1572–3). Concerning the third factor (3), Hauser, Chomsky, and Fitch (2002) made a distinction between the FL in a narrow sense (FLN) and in a broad sense (FLB): FLN refers to the aspects of language which are a unique component of the FL in human beings (i.e., the computational mechanism of recursion), whereas FLB refers to the FL in its entirety which is shared with other cognitive abilities. Because ERPs, which the present study employed, are one of the most advanced and reliable neurophysiological techniques to explore cognitive processes in the brain, research on language acquisition and processing using ERPs could be beneficial to explore the nature of FL and the third factor from the viewpoint of evolutional biology.

UG operates for L1 acquisition. It, however, is still controversial whether or not UG operates for L2 acquisition as well as L1 acquisition. Taking into consideration that human beings are able to command multiple languages, it is a matter of great importance to investigate the mechanisms of L2 acquisition as well as those of L1 acquisition for exploring the nature of FL. Therefore, we must examine how UG has been approached in research on L2 acquisition in the next chapter, chapter 2.

Chapter 2

Second Language Acquisition

Chapter 2 focuses on L2 acquisition. Firstly, section 2.1 introduces competing hypotheses in generative L2 acquisition. Then, section 2.2 critically evaluates studies of L2 acquisition from two perspectives to account for L2 learners' morphological variability: the Missing Surface Inflection Hypothesis (MSIH) (Prévost & White, 2000) and the Representational Deficit Hypothesis (RDH) (Tsimpli, 2003). Lastly, section 2.3 summarizes the predictions of these two hypotheses.

2.1 Competing Hypotheses of L2 Acquisition

Chomsky (1965) made a fundamental distinction between *competence* and *performance*. Competence refers to "the speaker-hearer's knowledge of his language" (Chomsky, 1965, p. 4). Performance, on the other hand, refers to "the actual use of language in a concrete situation" (ibid, p. 4). Many researchers have investigated the competence of native speakers based on the theory of UG, and they have also tried to incorporate the theory in research on L2 acquisition since the 1980s. English has attracted the most attention in developing the theory of UG and exploring the nature of FL, and hence L2 acquisition researchers, especially on English acquisition as a L2 or as a foreign language including English acquisition by JLEs, have a solid theoretical background. This fact enables the researchers to explain the problematic phenomena in L2 learners and discuss them on the basis of the theory of UG.

Non-native language in the course of L2 acquisition is referred to as *interlanguage grammar* (e.g., Corder, 1967; Selinker, 1972). Researchers on interlanguage grammar have argued that interlanguage grammar is systematic: The errors by L2 learners do not consist of random errors, but are constrained by UG. Although researchers have agreed the accessibility to UG for L2 acquisition to some extent with the development of linguistic theory and research on L2 acquisition, it is still controversial whether or not the course of L2 acquisition is identical in nature to that of L1 acquisition, and what factors cause the difference between L1 and L2 acquisition.

In the framework of the MP, UG is presumed to involve C_{HL} and the Lexicon. The lexicon consists of lexical and functional categories, and parametric variations among languages are assumed to be associated with the properties of functional categories. Therefore, language learning is believed to involve the setting of lexical items, and in particular with functional categories. Figure 2.1 illustrates the model of L1 acquisition and Figure 2.2 that of L2 acquisition, respectively, within the framework of the MP. In the figures, PLD stands for the "primary linguistic data," which language learners are exposed to. In Figure 2.2, "S_0" in Initial State and "S_S" in Steady State of grammar have been focused on in research on L2 acquisition within the framework of the MP.

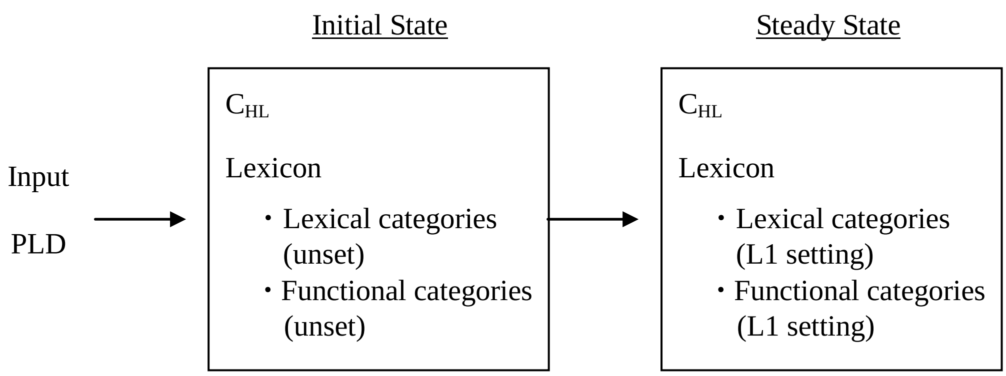


Figure 2.1. The model of L1 acquisition.

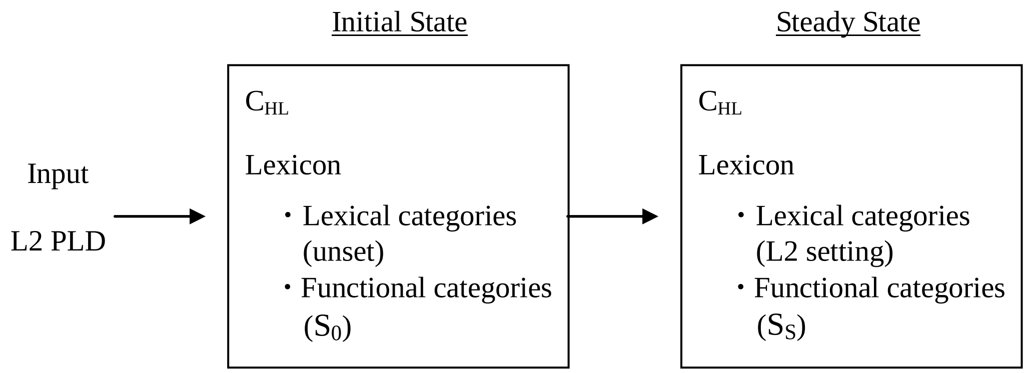


Figure 2.2. The model of L2 acquisition.

In earlier approaches to UG for L2 acquisition, Cook (1988) proposed three alternative models for the accessibility to UG for L2 acquisition: (1) *direct access* to UG, suggesting that L2 learners use UG without any reference to L1 competence; (2) *indirect access* to UG, which suggests that L2 learners use L1 competence in order to acquire their L2; and (3) *no access* to UG, which suggests that UG is available only for L1 acquisition, and therefore L2 learners use other faculties in order to acquire their L2.

Cook (1988) claims that one of the differences between L1 and L2 acquisition is that L2 learners already have their L1, and they could have acquired their L2 at any age. Cook explained the age factor for L2 acquisition within the critical period hypothesis (CPH). The critical period is referred to as a time of the early stages of an organism during which it displays a kind of heightened sensitivity to certain environmental stimuli. Without the appropriate stimuli, the organism is unable to develop or never develop the related function later in life. For example, the 1800s amateur biologist Douglas Spalding observed that a graylag goose becomes attached to a parent within the first 36 hours after hatching, which suggests that there is a critical period for imprinting during early postnatal development. The CPH for human beings was first proposed by Penfield and Roberts (1959) with a neurosurgical technique and popularized by Lennneberg (1967). Lenneberg (1967) states that maturational effects constrain L1 acquisition, which rely on brain plasticity, and then some aspects of language cannot achieve full mastery once the hemispheric development in the brain is complete. A distressing example is the case of Genie, who had been kept locked up and deprived of speech input until the age of 13 due to child abuse by her father. Once taken care of and exposed to intensive linguistic input, she expanded her vocabulary enormously. Her syntax, however, never developed completely. These observations have led to a critical period for certain functions in an organism including aspects of language acquisition by human beings, and it is reasonable to assume that the ability to acquire new languages disappears at a particular point of maturation, in the early teens, and consequently language learners cannot access UG after the critical period.

The terms discussed by Cook (1998), such as direct access, indirect access, and no access to UG, seem to be somewhat problematic in the sense that indirect access refers to both indirect and direct access, and no access is sometimes referred to as indirect access (White, 2003). Therefore, these terms have been replaced with other terms with the development of the related hypotheses. Each of the hypotheses of L2 acquisition introduced below predicts "S_0" in Initial State and "S_S" in Steady State in Figure 2.2. Table 2.1 summarizes the predictions in the competing hypotheses introduced below in this section. The predictions of the setting of functional categories in Initial state and that in Steady state in Table 2.1 could replace "S_0" and "S_S" in Figure 2.2, respectively.

Firstly, the term *direct access* has been replaced with the term *full access*. For one of the full access positions, Epstein, Flynn, and Martohardjono (1996) proposed the Full Access without Transfer Hypothesis. This position predicts that UG is the initial state of L2 acquisition, and then UG is available in interlanguage grammar without any reference to L1 representations. On the other hand, Schwartz and Sprouse (1996) proposed the Full Transfer Full Access Hypothesis, arguing that L1 steady state grammar corresponds to the initial state of L2 acquisition, and then UG is available in interlanguage grammar in reference to L1 representations. The Missing Surface Inflection Hypothesis (MSIH) proposed by Prévost and White (2000) is consistent with the Full Transfer Full Access Hypothesis. The MSIH predicts that UG is fully available to L2 learners and they are able to establish target-like syntactic representations using sufficient exposure to the target language, although L2 learners have a problem representing the phonological forms of the morphology. Putting a focus on how morphology is represented prosodically in L2 interlanguage, Goad and White (2004) proposed the Prosodic Transfer Hypothesis (PTH). The PTH predicts that "If the L1 does not permit certain kinds of prosodic representations as required by the L2, then second language speakers will have difficulties in representing such morphology in the outputs of the phonological component of the interlanguage grammar" (Goad & White, 2004, p. 122).

The second term, *indirect access*, has been replaced with the term *partial access*. One of the hypotheses, which involve the partial access position, is the Failed Functional Features Hypothesis (FFFH) proposed by Hawkins and Chan (1997). The FFFH predicts that late L2 learners are able to access UG only partially after the critical period. Functional features that are not present in their L1 are subject to the critical period, and consequently late L2 learners are no longer able to acquire the features. They, however, are able to acquire functional features that are present in their L1 together with the other features. Proposing the Representational Deficit Hypothesis (RDH), Tsimpli (2003) focused on deficits in acquiring uninterpretable features in late L2 learners even with advanced L2 proficiency. The Local Impairment Hypothesis proposed by Beck (1998a) also takes the partial access position, and claims that feature strength associated with verb raising is permanently impaired in L2 learners at any L2 developmental level, resulting in optional verb raising. The Local Impairment Hypothesis differs from the FFFH/the RDH in that the former suggests the impairment only occurs in relation to the feature strength, whereas the latter argues for the influence of the critical period on acquiring new functional categories and functional/uninterpretable features.

Lastly, *no access*, which implicitly involves the indirect access position, has been replaced by the Fundamental Difference Hypothesis proposed by Bley-Vroman (1990) and related arguments. The hypothesis predicts that children's L1 acquisition and adults' L2 acquisition are different in many respects: Interlanguage grammar in adult L2 learners is not constrained by UG or constrained partially by UG via L1 grammar. In consequence, UG, which enables L1 acquisition, is no longer available to adult L2 learners.

Table 2.1

Predictions in Competing Hypotheses of L2 Acquisition

			Setting of functional categories	
Access	Cook's term	Hypothesis (Study)	Initial state	Steady state
Full	Direct	The Full Access without Transfer Hypothesis (Epstein, Flynn, & Martohardjono, 1996)	Unset	L2
	Direct/Indirect	The Full Access Full Transfer Hypothesis (Schwartz & Sprouse, 1996)	L1	L2 possible
		The Missing Surface Inflection Hypothesis (Prévost & White, 2000)	L1	L2 possible
		The Prosodic Transfer Hypothesis (Goad & White, 2004)	L1 (prosodic)	L2 (prosodic) possible
Partial	Indirect/No	The Failed Functional Features Hypothesis (Hawkins & Chan, 1995)	L1	Before or during the critical period: L2 possible After the critical period: L1
		The Representational Deficit Hypothesis (Tsimpli, 2003)	L1	Before or during the critical period: L2 possible After the critical period: Uninterpretable features → L1 Interpretable features → L2 possible
		The Local Impairment Hypothesis (Beck, 1998a)	L1 (feature strength is inert)	L1 without feature strength
(No)	No/Indirect	The Fundamental Difference Hypothesis (Bley-Vroman, 1990)	No UG or/UG with L1	L2 possible

2.2 Studies of L2 Acquisition

As mentioned in the previous chapter, one of the most important questions in research on L2 acquisition is “why L2 learners make errors.” Concerning L2 morphosyntax, it is well known that L2 learners use verbal and nominal inflections variably or optionally under circumstances in which native speakers obligatorily use inflectional morphology. The *bottleneck* is a metaphor that has been used by Slabakova (2006, 2008) expressed in her Bottleneck Hypothesis, which indicates that functional morphology is the bottleneck of L2 acquisition for allowing the flow from L2 syntax and semantics, and even pragmatics, into a bottle smoothly.

There are two main perspectives in recent research on L2 acquisition within the framework of the MP to account for L2 learners’ morphological variability.

The first perspective involves the full access position, where L2 learners’ morphological variability is assumed to not be a competence problem but rather *a performance problem*. One hypothesis that has been proposed to attempt to account for the morphological variability in performance is the MSIH. The main prediction of this hypothesis is that L2 learners are able to establish target-like syntactic representations, although they have a problem connecting the phonological forms with syntactic representations in speech production.

The second perspective involves the partial access position, where L2 learners’ morphological variability is assumed to be due to *a permanent deficiency at the computational level* in acquiring certain functional features (not present in L1) rather than due to performance errors. This perspective is referred to as the FFFH. The term functional features in the FFFH has been replaced with the term uninterpretable features as the hypothesis has been developed into the RDH. The main prediction of the FFFH/the RDH is that functional/uninterpretable features that have not been selected during the critical period are not available, and therefore the interlanguage grammar of L2 learners, even with advanced L2 proficiency, is determined by the inventory of the functional/uninterpretable features of L1. Consequently, some divergences in non-native speakers are due to the influence of language representational differences and the divergences cannot be explained solely by performance factors.

In the rest of this section, some studies of L2 acquisition, which support either the MSIH or the FFFH/the RDH are critically evaluated. Each study evaluated in this section focused on more than one functional category, which is responsible for the morphological representations, because language acquisition is believed to involve the setting of functional categories within the framework of the MP. Table 2.2 summarizes the properties of some functional categories in English in terms of the associated formal features and their morphological representations.

Table 2.2

Properties of Functional Categories in English

Functional category	Formal features	Morphological representations
Determiner	[definite], [Case], φ-features ([person]/[number])	*a*, *the*, Ø morphemes
Pronoun	[Case], φ-features ([person]/[number])	-*s*, Ø morphemes
Complementizer	[wh]	*that*, *whether*, Ø morphemes
Inflection/Past	[finite], [EPP], [tense] ([present]/[past]), φ-features ([person]/[number])	-*s*, -*ed*, Ø morphemes

In Table 2.2, there is no one-to-one correspondence between formal features and their morphological representations. For example, although both *go* in *I go to work every day* and *goes* in *She goes to work every day* carry tense feature [present] of T, their morphological forms associated with [present] is represented in different ways on:

The [present] is not morphologically represented for *go* with a Ø morpheme attached to the end of the V *go* for the 1st-person singular-number subject PRN *I*, whereas it is morphologically represented with *-es* attached to the end of the V *go* in *goes* for the 3rd-person singular-number subject PRN *She*. The Case feature [Case] of PRN in the examples is represented as a distinct Case form (e.g., nominative *I* = subject position and accusative *me* = object position) as a consequence of Agree.

2.2.1 The Missing Surface Inflection Hypothesis

In this section, four studies that refer to the MSIH (Prévost & White, 2000) are examined. The discussions in these studies are mostly based on production data, and focuses on L2 learners' acquisition of formal features associated with verbal inflection (Haznedar & Schwartz, 1997; Ionin & Wexler, 2002; Lardiere, 1998a, 1998b, 2000, 2002), Case (Lardiere, 1998a), and verb raising (Lardiere, 1998b; Prévost & White, 2000).

2.2.1.1 Haznedar and Schwartz (1997)

Haznedar and Schwartz (1997) conducted a longitudinal case study with a boy called *Erdem*, who emigrated from Turkey to the United Kingdom. His L1 is Turkish and L2 is English. He was four years old attending a nursery school two and a half hours a day when the case study begun. His spontaneous production data had been collected three times a month for 18 months. Erdem had no exposure of English in Turkey, and communication with his parents was only in Turkish in the United Kingdom. The authors examined Erdem's development of English acquisition focusing on a language development stage known as Optional Infinitives (OI) or Root Infinitives (RI). The OI is a stage in which "a. finite and non-finite forms are in free variation and b. the finite forms have moved to their correct position" (Wexler, 1994, p. 311), and is a phenomenon that "cross linguistically young children acquiring non-null subject language go through a period in which they consistently alternate between finite and nonfinite verbs in main clause declarative sentences, while adult grammar requires a finite form" (Haznedar & Schwartz, 1997, p. 257). An example of OI by French children is shown in (1), which is taken from Pierce (1992), in which the non finite form *manger* "*eat-infl* (infl = inflection)" "to-eat" is used instead of its finite form.

(1) pas *manger* la poupée$_{subj}$
not *eat-inf* the doll
"The doll does not eat."

(Haznedar & Schwartz, 1997: 257)

Firstly, the authors found that Erdem had produced finite and nonfinite Vs alternately for an extended period, and he had gradually developed the correct use of verb morphology; his development is similar to that of OI in English native children. The examples of Erdem's utterances are shown in (2), in which he produced finite V *said* and non-finite V *say* alternately.

(2) a. She just *said* please please don't make noise. (S 28, 20 Jan. '95)
b. I want my mummy to hold me, she *say*. (S 28)

(Haznedar & Schwartz, 1997: 260)

Secondly, the authors examined Erdem's representations of subjects of the sentences, and found that he stopped producing null-subjects at an early stage at which he still produced finite and nonfinite Vs alternately, and that the null subjects occurred only with uninflected verb forms when he had produced null subjects early on. In contrast to the first finding, the results suggest that he went through a qualitatively different stage from that of OI in English native children.

Additional findings showed that Erdem had not randomly produced 3rd person singular (3SG) -*s* for subject-verb agreement morphology. That is, whenever he used 3SG -*s*, it was used almost correctly, although he had omitted 3SG -*s* many times. Furthermore, his pronominal subjects were always nominative, which development is also different from that of OI in English native children because English children tend to produce Case errors on subject PRNs. This finding suggests that Erdem transferred the linguistic properties of his L1, Turkish, which requires nominative Case on subjects, into L2, English, and his nominative Case implicated his successful acquisition of the inflectional phrase (IP) (subject Agreement phrase [Agr_sP]/TP) in his L2. One out of only three errors for pronominal subjects produced by Erdem is shown in (3), in which he produced accusative *Me* instead of nominative *I* for a pronominal subject.

(3) a. Investigators: You've finished.

b. *Me* is finish. (S 8, 20 May '94)

(Haznedar & Schwartz, 1997: 263)

Together with these results, the authors argue that Erdem had knowledge of functional category IP (Agr_sP/TP) and its formal features associated with verbal inflection in English, but he had "a problem with just realizing the morphological form of finite verbs" (Haznedar & Schwartz, 1997, p. 266). This argument suggests that Erdem's uninflected verb forms indicated not OI, "but rather MIs-Missing Inflections" (Haznedar & Schwartz, 1997, p. 266).

This study succinctly illustrated Erdem's successful development on verbal inflection and Case marking for pronominal subjects, and suggests that his problem was due to missing inflections rather than faulty inflections. The authors, however, seem to fail to explain why he had success only in Case marking on pronominal subjects. Although the authors attributed the success to L1 transfer, the question of why only

Case marking demonstrated L1 transfer still remains.

2.2.1.2 Lardiere (1998a, 1998b, 2000, 2002)

Lardiere (1998a, 1998b, 2000, 2002) discussed an endstate L2 learner called *Patty*, who emigrated from China to the United States at the age of 22. Her L1 is Chinese (Mandarin and Hokkien) and L2 is English. Her spontaneous speech production in English after about 10 years (Recording 1) and over 18 years (Recording 2 and 3) of her immigration were analyzed in terms of her acquisition of past tense and pronoun Case in Lardiere (1998a), and 3SG -*s* and the absence of thematic verb raising over elements of sentential negation/adverbs (e.g., *I do not write in Chinese*/*I may also apply to Northeastern*) in Lardiere (1998b). In addition, past tense verb forms in her e-mails were analyzed in Lardiere (2002). Distribution of the four items, which were investigated in obligatory contexts, is shown in Table 2.3.

Table 2.3

Distribution of Past Tense, Case, 3SG -s, and No Verb Raising in a Series of Lardiere's (1998a, 1998b, 2002) Studies

Recording	Past tense	Case	3SG -*s*	No verb raising
Recording 1	34.78 % (24/69)	100 % (49/49)	4.76 % (2/42)	100 % (69/69)
Recording 2	34.85 % (191/548)	100 % (378/378)	0 % (0/4)	99.19 % (122/123)
Recording 3	33.82 % (46/136)	100 % (76/76)	4.54 % (1/22)	100 % (42/42)
E-mail	78.00 % (120/154)			

Note. Suppliance/Contexts are in parentheses. 3SG -*s*: all non-past 3rd person singular -*s* thematic Vs only; No verb raising: occurrence of no thematic verb raising over elements of sentential negation/adverbs.

Table 2.3 shows that Patty's performance on pronoun Case and no verb raising over negation/adverbs was perfect, suggesting that her morphological representations of pronoun Case and no verb raising over negation/adverbs was consistent with those of her L2 English. Conversely, her performance on past tense and 3SG -*s* in her speech production was quite low. Regarding the poor results of past tense -*ed*, Lardiere (2002) argues that Patty's performance was apparently a matter of concern but it was not at all because her e-mail data showed much higher performance on past tense, suggesting that she in fact acquired the formal feature of past tense. Her high performance on both pronoun Case in her speech production and past tense -*ed* in her e-mail could not be the virtue of L1 transfer because her L1 Chinese does not morphologically represent formal features of either pronoun Case or past tense. As for the problem that the morphological representations of the formal feature of past tense occurred just in her speech, Lardiere (2000) has referred to the problem as a *mapping problem* between formal features and their morphological representations in speech production by L2 learners. Lardiere (2002) also reported that the rate of the deletion of the word-final -*t*/-*d* consonant clusters in monomorphemes in Patty's speech was 97 % (205/211). This result suggests that she in fact acquired the formal features associated with past tense and 3SG -*s*, and that L1 phonological transfer was a reason for her poor performance on past tense -*ed* and 3SG -*s* in her speech production due to the lack of the word-final consonant clusters in Chinese, which are required in English.

Lardiere's studies provide various data and show evidence of L2 learners' morphological variability. Some of the interpretations of the data, however, are still questionable. Firstly, it is not revealed why Patty's performance on pronoun Case was perfect: Her performance on pronoun Case such as *it* and *its* could have been affected by her L1 phonological properties just the same way as her performance on past tense and 3SG -*s* was affected if L1 phonological transfer affected her poor results of past tense -*ed*. Secondly, it is also not revealed why her performance on no verb raising over negation/adverbs was perfect, whereas her performance on 3SG -*s* was extremely low. Although Lardiere (1998b) suggests accessibility to UG evidenced by perfect performance on no verb raising over negation/adverbs and L1 phonological transfer evidenced by poor performance on 3SG -*s*, it might be possible to consider that the results are due to L1 transfer of the morphological representations: Similar to English, Chinese lacks verb raising and the morphological representations of formal features associated with of 3SG -*s* (φ-features: [person][number]). Finally, the reason why the mapping problem appeared inconsistently through her speech production is also questionable.

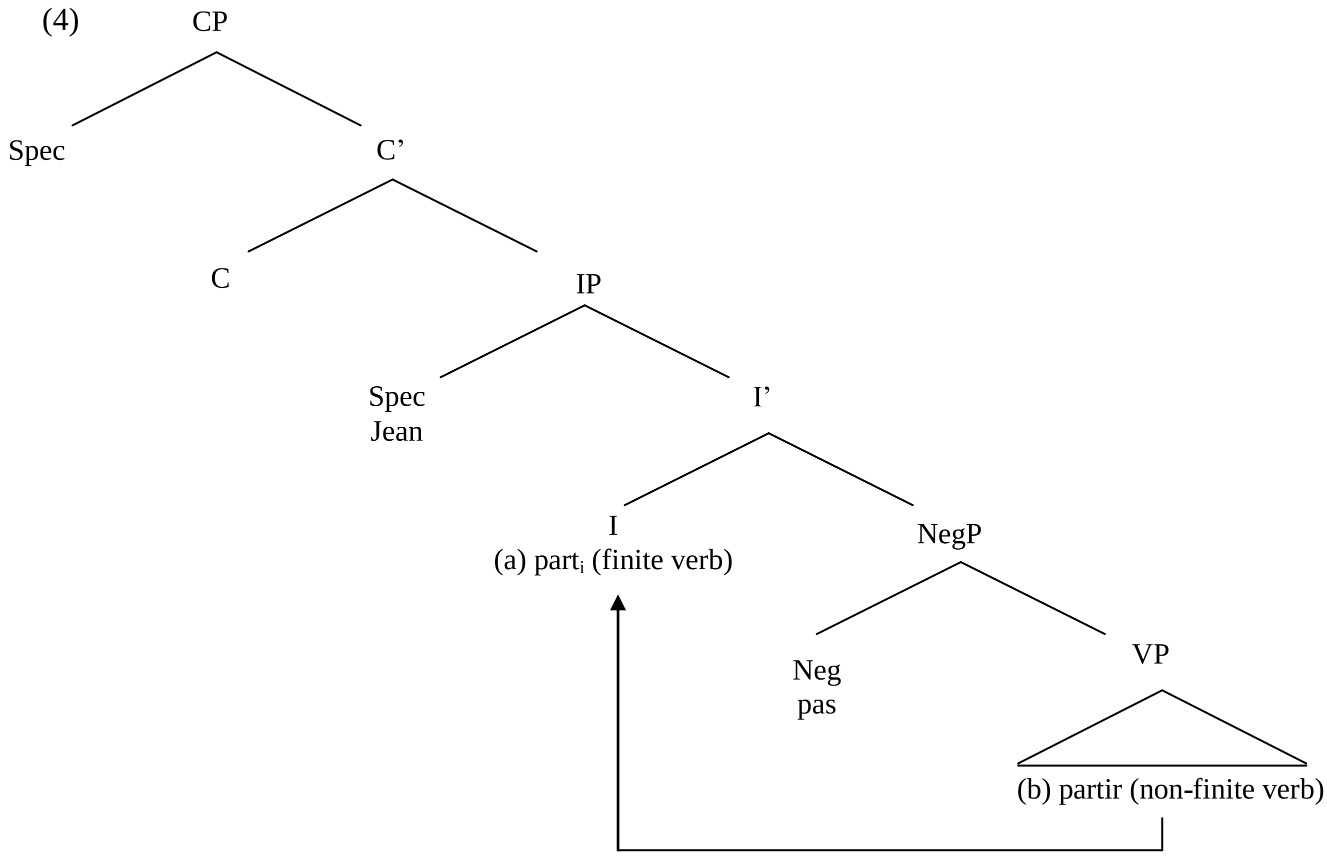
2.2.1.3 Prévost and White (2000)

Prévost and White (2000) examined L2 learners' acquisition of verb raising using production data by two adult L2 learners of French and two adult L2 learners of German. The data were based on interviews conducted by other researchers. In the L2 French group, *Adbelmalek* and *Zahra* are native speakers of Moroccan Arabic and emigrated from Morocco to France without any previous exposure to French. Their French proficiency was very limited when the data was collected. In the L2 German group, *Ana* is a native speaker of Spanish and *Zita* is a native speaker of Portuguese. Ana had previous exposure to German and school experience in Germany, whereas Zita did not have any experience in German before immigrating to Germany.

According to the analysis by the authors, V features[1] are strong in French and German so that a finite V in VP raises to I over negation/adverbs in a negation phrase (NegP) in French as shown in (4a), and raises through I to C in a main clause in German (V/I final) as shown in (5), leaving a trace *t* in its position where it was originally generated. A non-finite V, on the other hand, remains in the VP in both French as shown in (4b) and German.

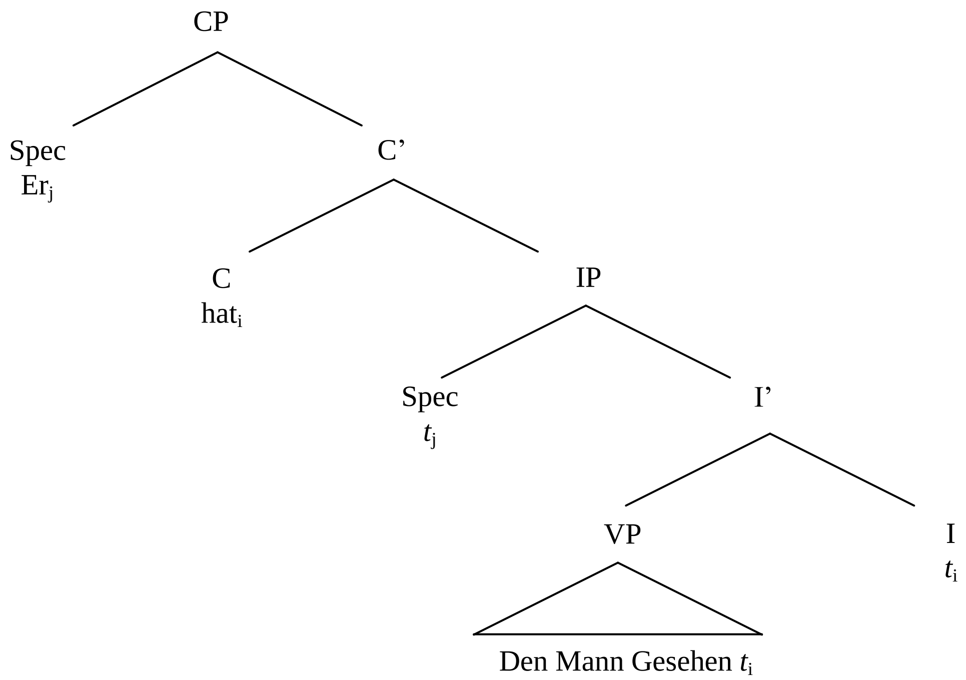
[1] V feature in Prévost and White (2000) might refer to the feature strength of I.

(4)



(Prévost & White, 2000: 105)

(5)



(Prévost & White, 2000: 105)

This study focused on both the L2 learners' verb forms and the placement with respect to negation. Firstly, a summary of the L2 learners' distribution of finite and non-finite forms is shown in Table 2.4.

Table 2.4

Distribution of Finite and Non-Finite Forms in Prévost and White (2000)

		Finite		Non-finite	
L2	Participant	+fin	–fin	+fin	–fin
French	Adbelmalek	98 % (767)	2 % (17)	47 % (243)	46 % (278)
	Zahra	98 % (755)	0.3 % (2)	59 % (224)	41 % (156)
German	Ana	98 % (385)	2 % (7)	37 % (45)	64 % (76)
	Zita	99 % (433)	1 % (6)	46 % (85)	54 % (98)

Note. Suppliance are in parentheses. +fin = finite context; –fin = non finite context.

As we can see from Table 2.4, the four L2 learners showed the same tendency in the use of verb forms regardless of their linguistic background. Non-finite forms were used in both non-finite (–fin) and finite (+fin) contexts by both the L2 French and L2 German groups, although the use of non-finite forms in +fin is ungrammatical in their L2. The examples of appropriate use of non-finite forms (i.e., infinitive forms) in –fin and those of inappropriate use of non-finite forms in +fin are shown in (6) and (7), respectively, in which PP and INF stand for past participle and infinitival form, respectively.

(6) a. il est *parti* l'Espagne, lui (Abdelmalek, month 14)
he is *gone-PP* the Spain him
b. Malika est *sortie* (Zaha, month 23.7)
Malika is *gone+out-PP* (fem.)
c. ich habe *gekommen* drei mal in Wohnung (Ana, month 11.7)
I have *come-PP* three times in house
d. meine Schwester hat nich *gesehen* (Zita, month 25.6)
my sister has not *seen-PP*
(Prévost & White, 2000: 115)

(7) a. il faut *parti* (Abdelmalek, month 27.7)
It must *leave-PP*
'We must leave.'/'One must leave.'
b. je peux *servi* (Zaha, month 23.7)
I can *serve-PP*
c. ich habe *machen* ein Jahre mehr (Ana, month 11.7)
I have *do-INF* one year more

d. mein Schwager is schon *gehen* (Zita, month 24.4)

my brother-in low is already *go-INF*

(Prévost & White, 2000: 115)

The reverse pattern, however, almost never occurred: Finite forms were obligatory used in +fin but were almost never used in –fin, which is grammatical in their L2.

Secondly, a summary of the L2 learners' distribution of verb placement with respect to negation is shown in Table 2.5.

Table 2.5

Distribution of Verb Placement with Respect to Negation in Prévost and White (2000)

		Finite		Non-finite	
L2	Participant	Verb–Negation	Negation–Verb	Verb–Negation	Negation–Verb
French	Adbelmalek	90	3	6	44
	Zahra	135	0	7	5
German	Ana	82	2	9	12
	Zita	74	4	4	29

Table 2.5 reveals that the four L2 learners systematically placed finite Vs before negation (e.g., *pas* in French and *nicht* in German), whereas they except Abdelmalek randomly placed non-finite Vs either before or after negation relative to finite Vs. The examples of appropriate verb raising (finite Vs before negation) by the four L2 learners are shown in (8), in which 1/2/3 stands for 1st/2nd/3rd person singular in phonetic form.

(8) a. mais on peut pas *dormir* (Abdelmalek, month 17.7)

but one can-1/2/3S not *sleep-INF*

b. i *mange* pas (Zaha, month 26.7)

he *eat-1/2/3S* not

c. ich *studiere* nicht (Zita, month 3.7)

I *study-1S* not

d. ich *spreche* nicht Deutsch (Ana, month 4.5)

I *speak-1S* not German

(Prévost & White, 2000: 117)

Based on the results, the authors conclude that the L2 learners were actually able to distinguish finite morphology from non-finite morphology, and that they substituted non-finite forms for finite forms because "non-finite forms are resorted to as a default" (Prévost & White, 2000, p. 125). These results suggest that formal features of finite Vs were present in their interlanguage grammar rather than being impaired: The L2 learners' problem was due not to *missing inflections* of formal features associated with non-finite Vs, but rather to *missing surface inflections* of them, which is proposed by the Missing Surface Infection Hypothesis. Referring to the mapping problem in Lardiere (2000), the authors speculated that the problem "might be due to a processing reason or to communication pressure, in which case one might expect the problem to affect different kinds of language use differentially" (Prévost & White, 2000, p. 129).

Examining the L2 learners' acquisition of verb raising as Lardiere (1998b) did, the authors focused on the verb forms as well as the verb placement with respect to negation. They modified the missing inflection hypothesis and termed it the Missing Surface Inflection Hypothesis. Nevertheless, not only was there the question of what systems made the appearance of non-finite forms as a default, as pointed out by the authors, but also the question of when the default would appear in L2 learners' speech. Furthermore, because there was no discussion of linguistic similarities or differences amongst the L2 learners' L1 and L2, it is not clear whether there was the effect of L1 transfer on their L2 acquisition of verb raising.

2.2.1.4 Ionin and Wexler (2002)

Ionin and Wexler (2002) investigated L2 learners' acquisition of verbal inflection by Russian children who immigrated to the United States for various lengths of time. The L2 learners' performance on affixal (3SG -*s* and past tense -*ed*) and suppletive (*be* auxiliary and *be* copula) agreement morphemes were examined using production data and an experiment.

Firstly, L2 learners' spontaneous production data were collected from a recording of their conversation with the authors. Twenty L2 learners (M_{age} = 8.40 years, age range: 3.90–13.10 years) participated in the interview. In this production study, the authors first examined omission and overuse of both types of morphemes in obligatory contexts, and found that the omission of affixal agreement morphemes was much higher than that of suppletive agreement morphemes. Further analysis of the use of affixal agreement morphemes showed that the L2 learners almost never overused affixal agreement morphemes. For example, the L2 learners omitted affixal agreement morphemes as shown in (9a), in which -*s* for V *play* is omitted for the 3rd-person singular-number subject DP *girl*. They, however, almost never overused affixal agreement morphemes shown in (9b), in which -*s* is supplied with V *like* for the 1st-person singular-number subject PRN *I*.

(9) a. girl *play* with toy
b. I *likes* costumes for Halloween for Batman

(Ionin & Wexler, 2002: 106)

In addition, analysis of the use of suppletive agreement morphemes showed that the L2 learners used suppletive agreement morphemes significantly more than affixal agreement morphemes. Contrary to affixal agreement morphemes, the L2 learners optionally overused suppletive agreement morphemes such as *is* in (10).

(10) a. the lion *is* go down

b. and then the police *is* come there

(Ionin & Wexler, 2002: 106)

In an additional analysis of the overuse of suppletive agreement morphemes, the authors suggest that "*be* is being used by the L2 learners to mark tense and/or agreement on the verb" (Ionin & Wexler, 2002, p. 112).

The results in the production study led the authors to conclude that the L2 learners were not impaired with regard to formal features underlying finiteness because the L2 learners used the morphemes where the morphemes were required, although the L2 learners tended to omit affixal agreement morphemes and overuse suppletive agreement morphemes.

In the experiment using a grammaticality judgment task, eighteen L2 learners (M_{age} = 10.30 years, age range: 6.00–14.00 years) participated in this experiment. Twelve of them were participants in the production study. The L2 learners were divided into groups with less or more advanced L2 (English) proficiency. Test items were single English sentences including good inflection with thematic Vs (e.g., *The boy likes cheese*) or auxiliary/copula (e.g., *The girl is little*), no overt inflection with thematic Vs (e.g., **The boy want the toy*) or auxiliary/copula (e.g., **The dog angry*), bad grammar with thematic Vs (e.g., **The children likes chocolate*) or auxiliary/copula (e.g., **We is sleep*), and dropped *ing* (e.g., **The man is sit on the chair*). The test was administered orally and the L2 learners were asked to respond whether the sentence was grammatical or not.

The results were reported in terms of accuracy and sensitivity to the types of item.

Firstly, in the results of accuracy[2] to the types of item, the more advanced learners group judged good inflection more accurately than the other types of items. On the other hand, the results in the less advanced learners group demonstrated the same tendency as those observed in the production study: The less advanced learners group performed better on auxiliaries than thematic Vs, and as well preferred overt inflection to bad grammar.

Secondly, in the results of sensitivity to the types of item, the L2 learners judged the sentences with auxiliaries significantly more accurately than thematic Vs, suggesting that the L2 learners were sensitive to the errors in auxiliaries more than thematic Vs. For example, the L2 learners were sensitive to errors as shown in (11b), in which auxiliary *is* is ungrammatically used instead of *are* for the 1st-person plural-number subject PRN *We*, more than errors as shown in (11a), in which -*s* is overused with a thematic V *like* for the 3rd-person plural-number subject DP *the children*.

(11) a. the children *likes* chocolate

b. We *is* sleeping

(Ionin & Wexler, 2002: 136)

Together with these results in the production study and the experiment, the authors argue that functional category T and its associated agreement features were present in the interlanguage grammars of the L2 learners, and the features were represented by the forms of suppletive agreement morphemes as evidenced by the overuse of suppletive agreement morphemes as shown in (11b). It is suggested that the omission or overuse of inflection was due not to the impairment or lack of the features,

[2] The participants' sensitivity to the different types of items was assessed by the A' measure, formulating A' = {0.5 + (y – x)(1 + y – x)}/4y (1 – x), where x is the percentage of 'yes' to overt inflection, bad grammar, or dropped -*ing*, and y is the percentage of 'yes' to good inflection (Ionin & Wexler, 2002).

but rather to a problem in the morphological representations of the features. The authors added that “retrieval and communication pressures may cause learners to sometimes leave out inflectional morphemes in production” (Ionin & Wexler, 2002, p. 128).

This study listed a variety of production data by the L2 learners and analyzed them by comparing the data with the results in the experiment. This research method is slightly different from the method in other studies, which support the MSIH, namely production data (Haznedar & Schwartz, 1997; Lardiere, 1998a, 1998b, 2000, 2002; Prévost & White, 2000). This study, therefore, provided a new way to evaluate the MSIH. In spite of the new research method, this study has some limitations. Firstly, the authors employed a judgment task for the child participants: The youngest was six years old. It is doubtful if such young participants made judgments properly in the experiment. Secondly, the authors listed the type of data in the dataset, however, it is noteworthy that some of it is questionable for supporting the MSIH (e.g., (9b) *I likes costumes for Halloween for Batman*, in which *-s* is overused with *like*), as the authors claimed that the L2 learners seldom produced these types of sentence. An explanation of such production by the L2 learners is required in order to support to the MSIH. Finally, although the number of participants in this study was larger than the other studies evaluated in this chapter (Haznedar & Schwartz, 1997; Lardiere, 1998a, 1998b, 2000, 2002), none of them overcame the retrieval and communication pressures. Therefore, the questions of who can overcome the pressure and how L2 learners win the pressures still remain.

2.2.2 The Representational Deficit Hypothesis

In this section, four studies that refer to the FFFH/the RDH are examined. In contrast to the studies which support the MSIH mostly based on production data, the discussions in the studies which support the FFFH/the RDH are based on the data derived from the experiment using a grammaticality judgment task (Hawkins & Chan, 1997), a production task and an interpretation task (Franceschina, 2003), a cloze test and a production task (Hawkins & Liszka, 2003), and a truth value judgment task (Hawkins & Hattori, 2006). The focused formal features are [wh] (Hawkins & Chan, 1997; Hawkins & Hattori, 2006), [Case], [number], and [gender] (Franceschina, 2002), and [past] (Hawkins & Liszka, 2003).

2.2.2.1 Hawkins and Chan (1997)

Hawkins and Chan (1997) investigated L2 learners' acquisition of the functional feature [wh] in connection with English restrictive relative clauses (RRCs) using a grammaticality judgment task. The L2 learners in this study were regarded as post-critical-period learners (late L2 learners); L1 Chinese speakers or L1 French speakers. The L2 learners were divided into three groups based on their L2 proficiency level; elementary, intermediate, and advanced groups. English native speakers also participated in this study as a control group.

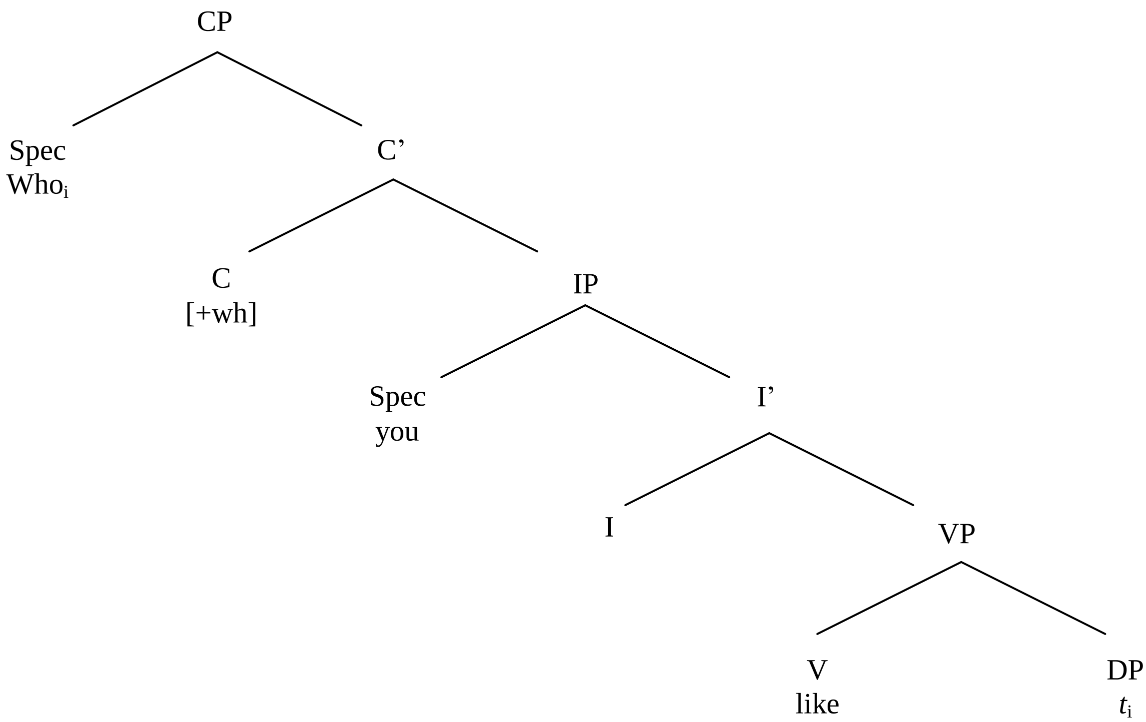
According to the analysis by the authors, there is a parametric difference in RRCs between English/French and Chinese: English and French have [wh] of C, which triggers *wh*-operator to move to [Spec, CP], whereas Chinese does not have [wh] of C. This parametric difference leads to the argument that English and French are languages with *wh*-operator movement in overt syntax, and Chinese is a language without *wh*-operator movement in overt syntax.

In English, [Spec, CP] in RRCs is introduced by a *wh*-operator, in other words, a *wh*-phrase such as *who* and *which*, or a null operator. A *wh*-phrase must move to [Spec, CP] overtly to check its [+wh] feature, leaving a trace *t* in its position where it was originally generated, as shown in (12) and its tree diagram in (13).

(12) The girl$_i$ [$_{CP}$ who$_i$ [I like t_i]] is here

(Hawkins & Chan, 1997: 190)

(13)



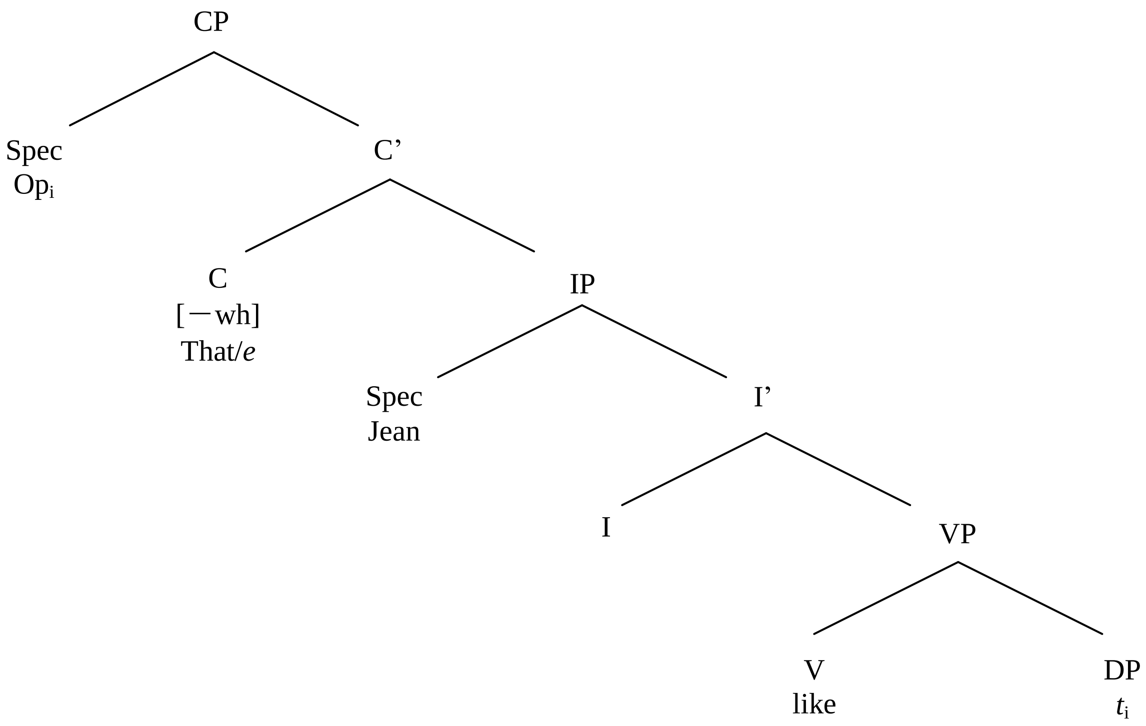
Similarly, a null *wh*-operator must move to [Spec, CP] for feature checking. When a *wh*-operator is null (OP), the head of CP is introduced by either *that* or null (*e*) ([–wh]) as shown in (14) and its tree diagram in (15). A *wh*-operator in [Spec, CP] cannot occur together with *that* or a presumptive PRN in the head of CP due to a feature clash between [+wh] of the Spec and [–wh] of the head of CP.

(14) a. The girl$_i$ [Op$_i$ that [I like t_i]] is here

b. The girl$_i$ [Op$_i$ e [I like t_i]] is here

(Hawkins & Chan, 1997: 190)

(15)



In contrast, in Chinese, the head of CP is introduced by a C (*ge* in Cantonese and *de* in Mandarin) instead of [wh], and then [Spec, CP] is introduced by a null PRN *pro*, which works for topic, or an overt presumptive PRN. The structure of Chinese RRCs is shown in (16) and in its tree diagram in (17).

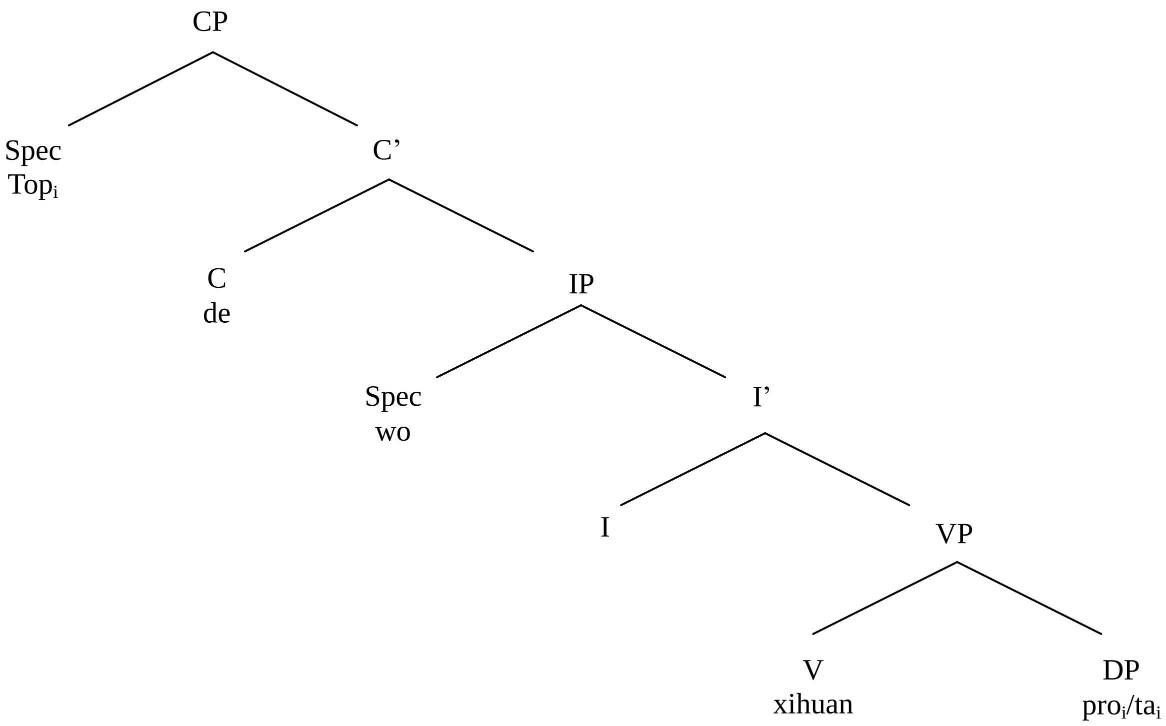
(16) $[_{CP}$ Top$_i$ $[_{IP}$ wo xihuan pro$_i$/ta$_i$] de] neige nuhai$_i$

null topic I like pro/her C the girl

The girl who I like

(Hawkins & Chan, 1997: 195)

(17)



Based on these analyses, nonviolation of subjacency, which is a principle of UG referring to a constraint on movement, is expected in Chinese RRCs because the relationship between *pro* and the fronted equivalent phrase is not connected by movement: It is a kind of binding dependency (e.g., Harada, 1972; Nishigauchi, 1986; Tsai, 1994) between a PRN and the antecedent, which is not subject to subjacency.

In the experiment, the test items were English grammatical RRCs (e.g., *The actor who performs well wins a lot of prizes*) and ungrammatical RRCs including the sentences where [Spec, CP] was filled with a *wh*-operator and *that* (e.g., **The girl who that lost her way cried*) or a presumptive PRN (e.g., **The man who he lives next door has left*) (doubly filled CP), and the sentences violating subjacency (e.g., violation of the *wh*-island constraint: **This is the man who(m) Mary told me when she will visit*; violation of the complex NP constraint: **This is the secretary who(m) Peter heard the news that the boss will marry*). The number of participants in each group and the results of the experiment are shown in Table 2.6.

Table 2.6

The Mean Judgment Accuracy in Hawkins and Chan (1997)

			Ungrammatical RRCs		
Group	L2 proficiency level (*n*)	Grammatical RRCs	Doubly filled CP	Presumptive pronouns	Subjacency violation[a]
L1 Chinese	Elementary (47)	56 %	50 %	38 %	67 %
	Intermediate (46)	67 %	68 %	55 %	58 %
	Advanced (54)	79 %	83 %	90 %	40 %
L1 French	Elementary (33)	81 %	91 %	81 %	66 %
	Intermediate (44)	88 %	95 %	90 %	72 %
	Advanced (40)	92 %	98 %	96 %	87 %
English native speakers (*n* = 32)		96 %	99 %	98 %	91 %

Note. RRCs = restrictive relative clauses
[a] Total scores of violations of the *wh*-island and NP constraints.

Table 2.6 shows that the L1 French group performed better than the L1 Chinese group at every L2 proficiency level. The judgment accuracy in the L1 French group at every L2 proficiency level did not significantly differ from that of the English native speakers on almost all types of RRCs. Table 2.6 also shows the significant improvement of judgment accuracy on all types of RRCs with increasing proficiency level in both the L1 Chinese and L1 French groups with an exception of subjacency in the L1 Chinese advanced group. For the result of low performance on subjacency in the L1 Chinese advanced group, the authors maintained that "with proficiency Chinese speakers do not acquire *wh*-operator movement, but analyze the gap as a null presumptive pronoun *pro*" (Hawkins & Chan, 1997, p. 213). From the overall results, the authors concluded that the L1 Chinese group at every L2 proficiency level had acquired the representations of English RRCs which did not involve *wh*-operator movement but involved a pronominal binding relationship because the L1 Chinese group still used the analysis based on the properties of their L1.

In discussion, the authors proposed the Failed Functional Features Hypothesis:

> the virtual, unspecified features associated with the initial state of functional categories like C, Agr, D, and which determine parametric differences between languages, are available in that form only for a limited period in early life. Exposure to samples of language during that critical period fixes the values of the features and associates them with particular morphophonological representations. Beyond the critical period the virtual, unspecified features disappear, leaving only those features encoded in the lexical entries for particular lexical items (like *that*, in the case of English predicative complementizer). The principles of UG, however, remain fully available and constrain grammar building. (Hawkins & Chan, 1997: 216)

This study revealed an asymmetrical difference on the basis of the L2 learners' L1, and found the effect of L1 transfer on L2 learners' acquisition of the functional feature [wh]. In addition to L1 transfer, L2 learners' age of L2 acquisition and L2 proficiency level were properly controlled to be equal between the L1 Chinese and L1 French groups. One of the limitations in this study is related to the notion of the critical period: The L2 learners in this study were regarded as post-critical-period learners.

Some of them in the L1 Chinese group, however, had started learning English in a classroom setting at the age of six. Referring to some studies of L2 acquisition, the authors claim that a reliable predictor for the age of L2 acquisition is only the "age of arrival in a community where the L2 is used for normal communicative purpose on a daily basis" (Hawkins & Chan, 1997, p. 201). Does it mean the situation where students study English as a foreign language in a classroom setting in Japan is counted as no exposure to English? The specific definition of differences between classroom exposure to L2 and other exposure to L2 such as immersion is required for a discussion on the effect of the age of L2 acquisition. Similarly, although the authors make claims on the basis of their results in post-critical-period learners (late L2 learners), the comparison of the results in late L2 learners and those in L2 learners who acquired their L2 during the critical-period (early L2 learners) may lead to support the FFFH. If the comparison shows evidence that only the early L2 learners had acquired the functional features that not been selected during the critical period, it would lend further support to the FFFH.

2.2.2.2 Franceschina (2002)

Franceschina (2002) examined L2 learners' acquisition of uninterpretable features [*u*Case][3], [*u*number], and [*u*gender] in Spanish. L2 learners in this study had high Spanish proficiency, and were divided into two groups: [–gen] group, in which the L2 learners' L1 was English, which has [*u*Case] and [*u*number] but does not have [*u*gender]; and [+gen] group, in which the L2 learners' L1 was French, German, Greek, Italian, and Portuguese, which has [*u*gender] as well as [*u*Case] and [*u*number]. Spanish native speakers also participated in this study as a control group. The author conducted two experiments using a production task and an interpretation task. Both of the tasks

[3] *u* = unvalued. An unvalued feature is equivalent to an uninterpretable feature. Capitalized Case, which is valued via syntactic agreement, is different from inherent case, which applies to arguments whose case is selected in the lexicon and which is typically selected based on specific theta-roles and is sensitive to semantic features such as animacy (Franceschina, 2002).

required knowledge of the morphological representation systems of [*u*Case], [*u*number], and [*u*gender].

The first experiment was conducted using a missing pronouns task. In this task, the participants provided a pronoun, which is inflected properly with Case (accusative/dative), number (singular/plural), and gender (masculine/feminine/neutral) for a sentence with one word missing. The number of participants in the first experiment was 25 in the [+gen] group, 15 in the [–gen] group, and 25 in the control group. An example of the test items is shown in (18), in which the pronoun in brackets was not provided in the test and was the expected answer.

(18) Los dos enchufes que compré estaban fallados. ¿Será posible cambiar (los) pro unos nuevos?

"The two plugs I bought were faulty. Could I change (them) for new ones?"

(Franceschina, 2002: 79)

The result in the first experiment showed that the [–gen] group (28 in total) made more errors than the [+gen] group (17 in total) and the control group (9 in total). In particular, the [–gen] group (11 out of 28) made more errors in gender than the [+gen] group (2 out of 17) and the control group (2 out of 9).

In order to further investigate L2 learners' acquisition of [*u*gender], the second experiment was conducted using a guessing game. In this second task, the participants guessed an object or a concept mentioned in a sentence by selecting one of the three nouns or adjectives provided in a list. The number of participants in the second experiment was 29 in the [+gen] group, 15 in the [–gen] group, and 29 in the control group. An example of the test items and the answer list are shown in (19) and (20), respectively, in which the expected answer was c. *chocolates* in (20).

(19) Los trajo Martín y dijo que son para usted

them-$_{MASC}$ brought Martín and said that are for you

"Martín bought them and said that they were for you"

(Franceschina, 2002: 81)

(20) a. flores b. joyas c. chocolates

flower$_{(FEM)}$ jewels$_{(FEM)}$ chocolates$_{(MASC)}$

(Franceschina, 2002: 81)

The result in the second experiment showed that the mean score of accuracy in the [–gen] group (12.20 out of 16) was significantly lower than the [+gen] group (13.83 out of 16) and the control group (14.69 out of 16). There, however, was no significant difference between the [+gen] group and the control group.

The author concluded from the results of the two experiments that [*u*gender] was a persistent problem for the [–gen] group but not for the [+gen] group. On the other hand, [*u*Case] and [*u*number] were not problematic for either of the groups. The results suggest that there was the effect of L1 transfer on the L2 learners' interlanguage grammar.

The data obtained by this study showed an asymmetrical difference on the basis of the L2 learners' L1. The L2 learners' age of L2 acquisition, however, was not mentioned at all in this study. More crucially, the results in the second experiment, which showed that the mean score of accuracy in the morphological representations of [*u*gender] by the [–gen] group was significantly lower than the other groups, could be taken to be counterevidence against the RDH because the score reached such a high score of 12.2 out of 16. The mechanisms underlining L2 morphological representations of uninterpretable features without any knowledge of the features in L1 need to be explained. The mechanisms will suggest a possible solution strategy to the full access to

UG position for L2 learners whose L1 does not have uninterpretable features which their L2 requires.

2.2.2.3 Hawkins and Liszka (2003)

Hawkins and Liszka (2003) investigated L2 learners' acquisition of the formal feature [past] in English by five Japanese, two Chinese, and five German L2 learners of English with high English proficiency.

The authors refer to Patty's poor performance on past tense *-ed* in speech production. As mentioned earlier, Lardiere (2000) suggests that there is a mapping problem between formal features and their morphological representations in speech production by L2 learners. Concerning the mapping problem, Lardiere (2002) has argued that L1 phonological transfer caused poor performance on past tense in Patty's speech production because words in her L1 Chinese do not end with the *-t*/*-d* consonant clusters (e.g., *-kt* in *walked*, *-skt* in *asked*, and *-mpst* in *glimpsed*). Prévost and White (2000) speculated that the problem occurs when L2 learners are under communication pressure. In order to assess L1 phonological transfer, the authors employed two types of languages for the participants' L1: One of the types is German (L1 German group), in which words end with consonant clusters like English (e.g., *-nst* in *getanzt* "danced"), and the other type is Chinese and Japanese (L1 Chinese and L1 Japanese groups), in which words do not end with consonant clusters. The authors conducted two experiments using a cloze test and a production task. Both of the tasks required knowledge of the morphological representation system of past tense.

In the first experiment, the authors investigated the L2 learners' knowledge of verbal inflection for past tense in English by using a close test, where the participants filled a blank with a word (verb) inflected appropriately in context. The number of participants was two for the L1 Chinese group and five each for the L1 Japanese and the L1 German groups. The words were listed with the meanings at the top of the test. Half of them required simple past tense forms and the others involved nonce Vs (half for prototypical regular such as *string* (bare form) → *strung* (past tense form) and the other for prototypical irregular such as *spling* (bare form) → *splung* (past tense form). Fifteen English native speakers participated in the first experiment as a control group. The results in the first experiment showed that the frequency of inflected and uninflected forms did not significantly differ among the L2 learners groups, but it significantly differed between the L2 learner and control groups. Further analysis revealed that this significant low frequency in the L2 learner groups was due not to inflecting regular nonce Vs, but rather to inflecting irregular nonce Vs. Based on the overall results in the first experiment, the authors conclude that the L2 learners had knowledge of verbal inflection for past tense in English because they could categorize a word as either a regular or an irregular nonce V, although they might not know the morphological representation system of past tense, resulting in ungrammatical verbal inflection for past tense for irregular nonce Vs.

The second experiment was conducted using a production task. In the task, the L2 learners watched a film, and then they retold the story in the film. After that, they gave comments on happy and exciting scenes. The authors counted solely Vs unambiguously used in context, and found that the L1 Chinese group, in contrast to the first experiment, produced inflected regular and irregular past tense Vs in obligatory contexts significantly less than the L1 Japanese and the L1 German groups. In a subsequent study, the authors examined the absence of word-final consonant clusters in regular participles (e.g., *were scared of*, *be sliced*, and *is released*), monomorphemes (e.g., *most* and *kind*), and regular simple past tense forms (e.g., *worked*). The reason why regular participles were chosen as a test item is that they are equivalent to the regular simple past tense forms. The results in the second experiment are shown in Table 2.7.

Table 2.7

Distribution of the Word-Final -t/-d Consonant Clusters in Regular Participles, Monomorphemes, and Regular Simple Past Forms in Hawkins and Liszka (2003)

		Participles		Monomorphemes		Simple past	
L1	*-t/-d*	Present	Absent	Present	Absent	Present	Absent
Chinese		100 % (10)	0 % (0)	82 % (9)	18 % (2)	63 % (25)	37 % (15)
Japanese		100 % (23)	0 % (0)	96 % (27)	4 % (1)	92 % (137)	8 % (12)
German		100 % (55)	0 % (0)	100 % (48)	0 % (0)	96 % (52)	4 % (2)

Note. Scores are in parentheses.

The Table 2.7 shows that, the L1 Chinese group had fewer problems with the word-final consonant clusters in monomorphemes than regular simple past tense forms, which is in contrast to Patty's high deletion of word-final consonant clusters in monomorphemes reported by Lardiere (2002). This result suggests that the mapping problem, which is assumes to be caused by L1 phonological transfer, was not the ultimate cause for the poor performance on regular simple past tense forms by the L1 Chinese group: If it were the case, not only the L1 Chinese group but also the L1 Japanese group would show the same poor performance on monomorphemes because words in Japanese as well as Chinese do not end with consonant clusters. In addition to the fewer problems with the word-final consonant clusters in monomorphemes, the L1 Chinese group perfectly produced participle with word-final consonant clusters, suggesting that communication pressure was not the ultimate cause for the poor performance on regular simple past tense verb forms in the L1 Chinese group, either: If it were the case, the same results would be expected in all of the test items across the three L2 learners groups.

Together with the results in the two tasks, the authors argue that the poor performance on past tense in Lardiere's study of Patty was not caused by L1 phonological transfer, but by the lack of the morphophonological exponent of past tense which is not present in Chinese[4]. By contrast, Japanese and German have the morphophonological exponent of past tense like English: *-ta* for past tense and *-ru* for present tense in Japanese. The authors claim:

> the Chinese speakers have difficulty assigning the formal (i.e. syntactically-relevant) feature [past], which determines the morphophonological forms of verbs in English, to the feature inventory of the category T(ense) in the lexicon, because the feature is not selected in Chinese and is subject to a critical period. (Hawkins & Liszka, 2003: 24)

This study provided us with another perspective to evaluate the MSIH (Prévost & White, 2000), suggesting that Patty's problem in the morphological representations of past tense was in fact a breakdown in computation rather than missing surface inflections. In spite of the new approach, there are some problems in this study. Firstly, the number of participants was small, which the authors admitted: The participants in this study were only two for the L1 Chinese group, five each for the L1 Japanese and the L1 German groups. If there had been more participants in each group and also more groups of different L1s which do not have the morphophonological exponent of past tense like Chinese, the statistics may have had much more explanatory power. Secondly, the results in the second task showed that the L1 Chinese group had fewer problems with word-final consonant clusters in monomorphemes (score of 9, 82 %) than in regular simple past tense forms (score of 26, 63 %). However, one cannot tell if the difference was statistically significant. Similarly, although the L1 Chinese group produced regular simple past tense forms with word-final consonant clusters appropriately two-thirds of the time, the authors did not produce statistics or an

[4] Chinese has verbal aspect markers (e.g., *-le*, *-guo*, and *-zhe*), and hence Vs can be interpreted as past or present depending on contexts (Hawkins & Liszka, 2003).

explanation of the reasons for the results at all. There might have been some mechanisms which enabled the L1 Chinese group to produce them even though there is no morphophonological exponent of past tense in their L1 Chinese. Finally, but crucially, [past] is not uninterpretable feature, but rather interpretable feature. The feature, therefore, could not be subject to the critical period according to the RDH. Hawkins (2005) argues that Chinese lacks not only interpretable tense feature [tense: past] of T, but also uninterpretable tense feature [*u*tense] of *v*, both of which the late Chinese L2 learners of English would not be able to access[5].

2.2.2.4 Hawkins and Hattori (2006)

Hawkins and Hattori (2006) investigated L2 learners' acquisition of uninterpretable feature [*u*wh*:][6] associated with *wh*-movement in interrogatives in English by JLEs using a truth value judgment task. The JLEs had high English proficiency and had no experience in an English-speaking country before puberty (late L2 learners).

The authors assumed that there is a parametric difference between English and Japanese in *wh*-movement in interrogatives: English has [*u*wh*:] which forces the *wh*-movement, whereas Japanese does not have [*u*wh*:]. This parametric difference means that English is a language with the movement of *wh*-phrases to the front of the sentence (i.e., [Spec, CP]), and Japanese is a language without the movement. The authors predicted that [*u*wh*:] would not be available to the late JLEs.

The authors explained two types of *wh*-questions in English and Japanese. The first type is single *wh*-questions. In English, a *wh*-phrase must move to [Spec, CP] of a simple clause as shown in English (21a), or must move to [Spec, CP] of a matrix clause if the *wh*-phrase is located in an embedded clause as shown in English (22a). By

[5] This argument is discussed in chapter 4.
[6] Hawkins and Hattori (2006) did not define [*u*wh*:], but it seems that they used an asterisked [*u*wh*:] as an unvalued interpretable feature [wh], which is required to get valued and is specified on C based on the analysis in Adger (2003).

contrast, in Japanese, the *wh*-phrase can remain in the position of first-merged in both simple and matrix clauses as shown in the Japanese counterparts (21b) and (22b).

(21) a. What did Mary buy <what> yesterday?

b. Mary-wa kinou nani-o kaimashi-ta ka?

Mary-topic yesterday what-Acc buy-past Q?

(Hawkins & Hattori, 2006: 274)

(22) a. What did John remember [$_{CP}$ <what> mary bought <what> yesterday]?

b. John-wa [$_{CP}$ Mary-ga kinou nani-o kat-ta ka] oboete imasu ka?

John-topic [$_{CP}$ Mary-Nom yesterday what-Acc buy-past Q] remember is Q?

(Hawkins & Hattori, 2006: 274)

The second type of *wh*-question, multiple *wh*-questions, in which two *wh*-phrases appear in a sentence as shown in (23).

(23) Where did the professor say the student studied when?

(Hawkins & Hattori, 2006: 277)

The sentence (23) is grammatical and has two readings: One reading questions where the student studied and when they studied if *where* is assumed to be merged in the embedded clause at first and moved to [Spec, CP] of the matrix clause. The other reading questions when the students studied and where the professor said it if *where* is assumed to be merged at first in the matrix clause and moved to [Spec, CP] of the matrix clause. The questions in (24), on the other hand, are not grammatical.

(24) a. *? What did who buy?

b. *? Where did the professor say when the students studied?

(Hawkins & Hattori, 2006: 277)

The authors explained this ungrammaticality by Attract Closest Principle shown in (25).

(25) Attract Closest Principle

A head which attracts a given kind of constituent attracts the c*losest* constituent of the relevant kind

(Radford, 2004: 200)

As a consequence of the Attract Closest Principle, (24a) is ungrammatical because *who* is the subject of the clause CP and closer to the head C of CP than *What,* then *who* instead of *What* is required to move to [Spec, CP] (*superior violation*). Similarly, (24b) is ungrammatical because *when,* which is closer to the head of CP than *where,* is required to move from the embedded clause to [Spec, CP] of the matrix clause instead of *where* (*subjacency violation*). English applies the Attract Closest Principle to the interrogative *wh*-movement because English has [*u*wh*:], which forces the *wh*-movement. By contrast, in Japanese, *wh*-phrases can move in the same way as ungrammatical English examples in (24) as do their Japanese counterparts in (26) indicate, because Japanese does not have [*u*wh*:], or the movement is not forced by [*u*wh*:].

(26) a. Dare-ga nani-o kaimashi-ta ka?

who-Nom what-Acc buy-past Q?

b. Sono kyoujyu-wa itu sono gakuseitachi-ga dokode benkyoushi-ta

to iimashi-ta ka?

The professor-topic when the students-Nom where study-past

that say-past Q?

In this study, the questions consisted of: both of the violations (e.g., *Who did the weather office warn <who$_1$> [when the hurricane might strike <*who$_2$><when>]?*), either of the violations (e.g., superiority: *Who did Henry remember <who$_1$> [Sophie would telephone <*who$_2$> when]?*; subjacency: *When did Rupert discover <who$_1$> [who Nora had met <who><*who$_2$>]?*), or without the violations (e.g., unambiguous: *Who did the head teacher suspect [<who> had take what]?*; ambiguous: *When did Henry remember <when $_1$>[Louise had lost what <when $_2$>]?*). The results of 19 late JLEs who had high English proficiency and adequately interpreted long-distance *wh*-questions in a syntax test, and those of 19 English native speakers in a control group were reported. In the experiment, the participants read a story in their L1. Then, they were provided a bi-clausal multiple question orally in English and were supposed to choose any possible answers out of three orally in English, giving a score of *1* for the chosen answer and that of *0* for the unchosen answer.

In the results, the English native speakers chose the answers to the questions without the violations significantly more than those with either or both of the violations, and the choices of the answer to the questions was significantly different among the types of questions, suggesting that they were sensitive to the violations and the Attract Closest Principle. The JLEs, on the other hand, chose the answers to the questions with either or both of the violations significantly more than the English native speakers did, but there was no significant differences among the types of questions. Importantly, the choice of the answers to the questions without the violations was not significantly different between the English native speakers and the JLEs, suggesting that the JLEs were able to exhibit the target-like performance for the representations of grammatical interrogatives. From the overall results, the authors argue that the JLEs failed to represent [*u*wh*:] in English constrained by the Attract Closest Principle, although they were able to interpret the long distance *wh-word ... gap* dependencies. The authors conclude that there was the critical period effect for the late JLEs on acquiring [*u*wh*:], and that caution was required in interpreting the apparent target-like performance as evidence to show that the underlying representations in the L2 leaners was the same as that in native speakers.

There are some limitations in this study. Firstly, the number of the tokens used was too small: the maximum was four and just one for the questions with both of the violations. More tokens would be needed to show the validity of the experiment statistically. Secondly, the authors found that the choices of answers to questions without the violations was not significantly different between the English native speakers and the JLEs, and suggest that the JLEs were able to interpret the *wh-word ... gap* dependencies. If so, the question of what is the underlying mechanisms which caused the successful interpretation of the *wh-word ... gap* dependencies remains unclarified.

2.3 Summary of the Missing Surface Inflection Hypothesis and the Representational Deficit Hypothesis

The predictions in the MSIH and the RDH are summarized in Table 2.8 in terms of the following three factors; accessibility to UG, the critical period, and level of L2 learners' morphological variability.

Table 2.8

Summary of Predictions in the Missing Surface Inflection Hypothesis and the Representational Deficit Hypothesis

Factor	The Missing Surface Inflection Hypothesis	The Representational Deficit Hypothesis
Accessibility to UG	Full	Partial
The critical period	Full access to UG beyond the critical period	Partial access to UG after post-puberty
Level of the variability	Performance	Competence

Concerning the first and second factors, the MSIH predicts that L2 learners are able to fully access UG regardless of the age of L2 acquisition based on their L1, whereas the RDH predicts that L2 learners are able to access UG only partially because uninterpretable features that are not present in their L1 and are not selected during the critical period are no longer available, and consequently late L2 learners cannot acquire the features. This argument leads us to the prediction of the third factor, namely, the level of L2 learners' morphological variability. According to the MSIH, because L2 learners are fully able to access UG, there could not be any deficits in their L2 morphological representations: The L2 learners' problem, called the mapping problem in connecting the phonological forms with the syntactic representations of formal features due to L1 phonological transfer (Lardiere, 2000), appears at the performance level. The RDH, in contrast, insists that late L2 learners show deficits in acquiring uninterpretable features that are not present in their L1 and are not selected during the critical period, although they can exhibit the apparent target-like performance for the morphological representations of the features. Because the deficits are in the uninterpretable features in UG, their morphological variability reflects deficits in competence.

Consider poor performance on past tense in speech production by Patty. Based on the predictions set out by Prévost and White (2000), Patty actually acquired interpretable tense feature [past] of T in English. She, however, had a mapping problem between [past] and the morphological representations in English under certain situations such as communication pressure, because of the effect of L1 phonological transfer (the lack of the word-final -*t*/-*d* consonant clusters in her L1). The RDH, on the other hand, predicts that Patty was not able to acquire uninterpretable tense feature [*u*tense] of *v* because neither uninterpretable tense feature [*u*tense] nor interpretable tense feature [past] of T which allows morphosyntactic exponents of the past tense to determine the past tense verb forms are not present in Chinese, and consequently uninterpretable tense feature [*u*tense] was subject to the critical period effect (Hawkins, 2005).

Chapter 3 reviews studies of language processing using neurophysiological methods, mainly using ERPs, which the present study employed. Neurophysiological studies of L2 processing in bilinguals and L2 learners are reviewed in terms of these three effects on L2 acquisition and processing: the effects of the age of L2 acquisition, L2 proficiency level, and L1 transfer.

Chapter 3

Event-Related Brain Potential Studies of Second Language Processing

Chapter 3 reviews studies of language processing using neurophysiological methods, mainly using ERPs. First of all, section 3.1 gives an outline of ERPs. Section 3.2 reviews ERP studies of language processing in native speakers, and then section 3.3 reviews those of L2 processing in bilinguals and L2 learners in terms of the effects of the age of L2 acquisition, L2 proficiency level, and L1 transfer. At the end of section 3.3, developmental stages of L2 morphosyntactic processing in late L2 learners as indexed by ERP components are introduced. Finally, section 3.4 reviews some studies of L2 processing using functional Magnetic Resonance Imaging (fMRI), which is one of the other neurophysiological methods.

3.1 What are ERPs?

Since the 1980s the neurophysiological methods have been employed for the investigation of language acquisition and processing in addition to production data and behavioral methods such as grammaticality judgment and reaction time. The production data and the results derived from behavioral methods have actually shown differences and similarities between L1 and L2 acquisition and processing, but have not necessarily shown the underlying neuronal mechanisms associated with the behavioral. The employment of neurophysiological methods, however, can enable us to understand the underlying neuronal mechanisms. Among the neurophysiological methods, an electrophysiological technique such as Electroencephalography (EEG) and Magnetoencephalography (MEG) directly provides the data with high-temporal resolution which show the timing of processing in the range of milliseconds (ms), but less reliable information of the spatial regions of the activated brain. EEG is the continuous recording of electrical activity along the scalp produced by the flow of ions inside the neurons that fires in response to the information in the brain, and MEG measures a change in the magnetic field produced by electrical activity in the brain. A hemodynamic technique, which is the other type of neurophysiological method, such as Positron Emission Topography (PET) and fMRI indirectly provides the data with high-spatial resolution which show the spatial regions of the activated brain in the range of millimeters (mm), but less temporal information associated with the timing of processing. PET measures detected pairs of gamma rays indirectly by a positron-emitting radionuclide that is introduced into the body on a biologically active molecule, and fMRI measures a change in blood flow that is related to neural activity in the brain. Each technique has been employed appropriately according to the purpose of research.

The present study employed ERPs. ERPs can be obtained by averaging the electroencephalograms of subjects who are presented with a series of stimuli, which are expected to evoke some potentials in electroencephalographic activities. The ERPs, therefore, refer to scalp-recorded brain potentials that responds to external stimulation by various modalities such as visual or auditory, or to internal processes triggered by the stimulation. The procedure of averaging makes ERPs clearer by filtering out background electroencephalographic activities, which are irrelevant to the stimulation.

Because of the nature of electrical potentials, ERPs show positive and negative deflections, and these are referred to as ERP components. The ERP components are characterized by the following four parameters, which are indexes of the underlying processes: (1) *Polarity*, which indicates voltage changes of the components that are positive (P) or negative (N) relative to the baseline; (2) *Latency*, which indicates the post stimulus time course of the component, including onset latency (the time for the beginning of the component) and peak latency (the time for the attainment of the maximum amplitude); (3) *Amplitude*, which indicates the voltage degree of the component relative to the baseline; and (4) *Scalp topography*, which indicates the scalp regions of the component. Figure 3.1 shows the four parameters in ERP components. In a landmark ERP study of language processing, Kutas and Hillyard (1980) found N400 component. N in N400 stands for negative, and 400 in N400 means that the component peaks approximately 400 ms after the onset of a stimulus. Most of the ERP studies have linked the specific ERP component to the different types of linguistic processing across the different types of languages.

ERP studies of language processing mainly used violation paradigms, in which ERP differences of the waves are computed by subtracting a control ERP from the violation condition. For example, in the examination of semantic processing by Neville, Nicol, Barss, Forster, and Garrett (1991), the ERP responds to the critical word *speech* in the congruent sentence "Mike listened to Frank's *speech* about politics" was subtracted from the ERP responds to the critical word *orange* in the semantically incongruent sentence "*Mike listened to Frank's *orange* about politics."

ERPs can detect small quantitative differences (the relative degree of latency or amplitude of the component) and qualitative differences (presence or absence of the component, or distinct polarity or topography) in the time course and in the degree of neural activity during language processing between native speakers and L2 learners, and among L2 learners grouped by certain criteria such as the age of L2 acquisition, L2 proficiency level, and the linguistic properties of L1.

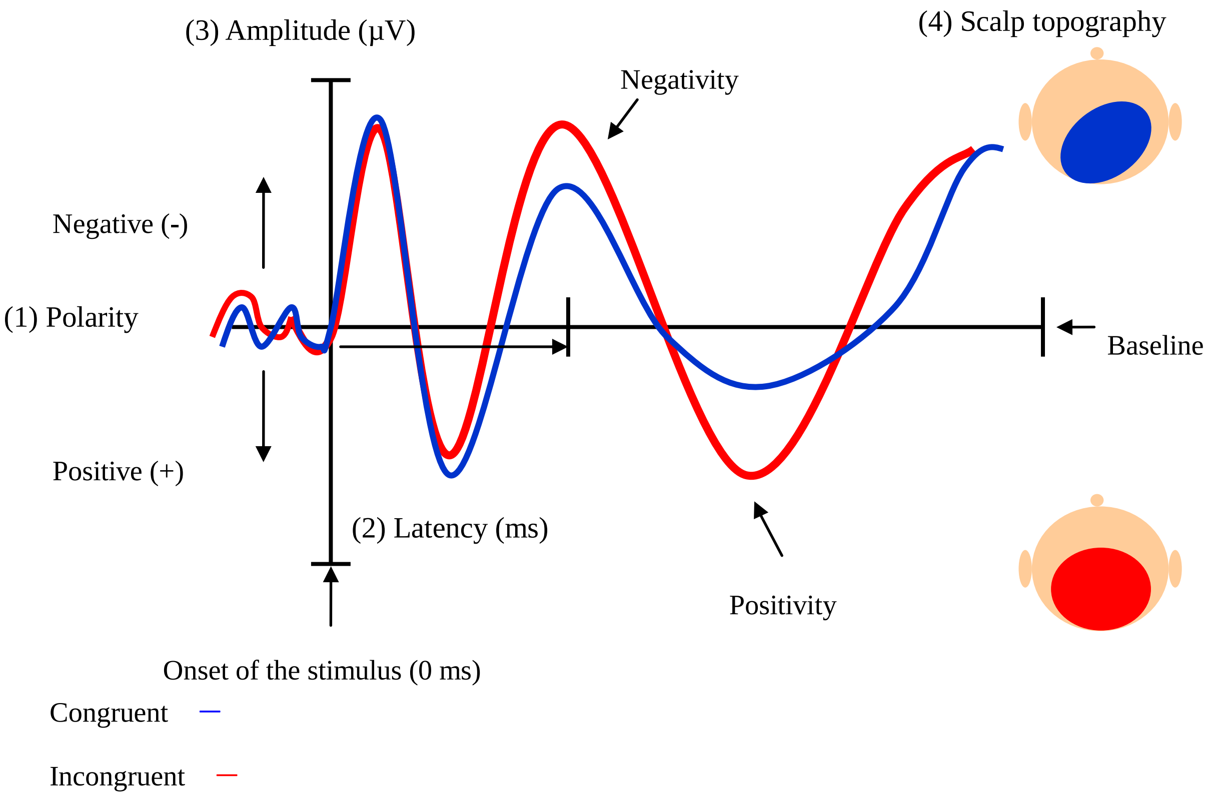


Figure 3.1. Four parameters in ERP components: (1) Polarity, (2) Latency, (3) Amplitude, and (4) Scalp topography.

3.2 ERP Studies in Native Speakers

Section 3.2 reviews ERP studies of semantic processing and morphosyntactic processing in native speakers.

3.2.1 Semantic Processing

Concerning ERP studies of semantic processing in native speakers, N400 is reported by Kutas and Hillyard (1980) in English native speakers. N400 is a negative component which latency peaks approximately 300 to 500 ms after the stimulus. It appears in the parietal and central regions of both hemispheres. Kutas and Hillyard (1980) was the first study which investigated language processing using ERPs.

The authors visually presented three types of English sentences: a sentence with strong semantic mismatches (e.g., *He took a ship from the *waterfall*); a sentence with moderate semantic mismatches (e.g., *He took a ship from the *transmitter*); and a sentence with the last word written in large font (e.g., She put on the high-heeled SHOES). The results showed that the amplitude of N400 increased as the stronger semantic mismatches were presented, and the large font was not associated with N400, but elicited P300. As an interpretation of N400, the authors state that "N400 is not a general response to all linguistic or meaningful stimuli because judgments about such stimuli have been especially associated with the P300 wave. Rather, the N400 seems to reflect the interruption of ongoing sentence processing by a semantically inappropriate word and the 'reprocessing' or 'second look' " (Kutas & Hillyard, 1980, p. 207).

The follow-up study argues that N400 is also elicited for the words with semantically low cloze probability for a given position in a sentence (Kutas & Hillyard, 1984). That is, as a word becomes more expected in context, the amplitude of N400 is reduced relative to a less expected word. Other studies have reported the decrease of N400 amplitude for the repeated same semantic violations (e.g., Besson, Kutas, & Van Petten, 1992), and the increase of N400 amplitude for the appearance of nonwords (e.g., Holcomb & Neville, 1990). Accordingly, N400 has been regarded as an indicator of the difficulty of semantic integration processing.

The recent N400 studies have highlighted the complex cognitive interactions of meaning, for example, with memory (Willems, Ozyurek, & Hagoort, 2008), learning (Reid, Hoehl, Grigutsch, Groendahl, Parise, & Striant, 2009), perception (Kelly, Kravitz, & Hopkins, 2004), and attention (Van Berkum, 2009).

3.2.2 Morphosyntactic Processing

In contrast to semantic processing, morphosyntactic processing in native speakers is associated with a set of components consisting of an early left anterior negative component (ELAN), a later left anterior negative component (LAN), and a late centro-parietal positive component (P600).

Neville et al. (1991) have investigated syntactic processing with semantic processing in English native speakers from the viewpoint of the GB theory. This study was among the first to investigate the relationship between linguistic theory and the brain using ERPs, and the following three conditions of English syntactic sentences that were accompanied by semantic expectations were visually presented: (1) phrase structure[1] (e.g., The man admired a sketch *of*/*Don's *of* sketch the landscape); (2) *wh*-movement constraints on specificity[2] (e.g., What did the man admire a *sketch* of/*Don's *sketch*?); and (3) subjacency[3] (e.g., Was a sketch of the landscape *admired* by the man?/*What was a sketch of *admired* by the man?). In the results, N400 was elicited in the bilateral posterior regions by the semantic anomalies predictably. In response to the violations of phrase structure and specificity, the authors also observed an early negative component, N125, which appeared in the anterior region of the left hemisphere and a later sustained negative component in the temporal and parietal regions of the left hemisphere with an onset that began approximately 300 ms and continued to approximately 500 ms after the stimulus. Moreover, a positive component in the occipital regions of both hemispheres, P600, was elicited in response to the violations of phrase structure and subjacency. Although neither the terms ELAN nor LAN are used in this study, early (N125) and later negativities are assumed to be ELAN and LAN, respectively. These results confirmed a relationship between biological support for distinct principles and constraints in linguistic theory and specific ERP components.

Friederici (2002) proposed a neurocognitive model, which consists of four phases (Phases 0[4], 1, 2, and 3) for sentence comprehension. In the model, the time windows of

[1] A preposition that introduces a modifying phase for a head N of the object NP appears to the left of the head N in English (Neville et al., 1991).
[2] A *wh*-phrase cannot be extracted from a specific or definite NP in English (Neville et al., 1991).
[3] A *wh*-phrase cannot be extracted from inside a subject NP in English (Neville et al., 1991).
[4] Friederici (2002) labeled the time window 100 ms of N100 Phase 0 for the identification of phonemes.

ELAN, LAN, and P600 were labeled Phase 1, Phase 2, and Phase 3, respectively. The properties of each phase are explained in each section below.

3.2.2.1 Early Left Anterior Negativity

ELAN is a negative component which peaks approximately 150 to 200 ms after the stimulus in the anterior regions of the left hemisphere. As Neville et al. (1991) observed ELAN in response to the violations of phrase structure and specificity, ELAN has been mainly observed in response to the violations of phrase structure (e.g., Friederici, Hahne, & Mecklinger, 1996; Friederici, Pfeifer, & Hahne, 1993; Hahne & Friederici, 1999). ELAN, therefore, has been regarded as an indicator of early automatic processing associated with the identification of word category. The time window from 150 to 200 ms of ELAN was labeled Phase 1 for the identification of word category in Friederici (2002).

3.2.2.2 Left Anterior Negativity

Similar to ELAN, LAN is a negative component that appears in the anterior region of the left hemisphere. It, however, is elicited slightly later than ELAN, peaking approximately 300 to 500 ms after the stimulus, which is the same time window of N400. Although LAN was elicited in response to the violations of phrase structure and specificity in Neville et al. (1991), it has been observed mainly in response to morphological violations: number disagreement (e.g., Coulson, King, & Kutas, 1998; Kutas & Hillyard, 1983; Münte, Matzuke, & Johanners, 1997; Weyerts, Penke, Dohrn, Clashen, & Münte, 1997); Case making violation (e.g., Coulson et al., 1998; Friederici & Frisch, 2000); gender violation (e.g., Barber & Carreiras, 2005; Gunter, Friederici, & Schriefers, 2000); and tense inflection violation (e.g., Gunter, Stowe, & Mulder, 1997; Kutas & Hillyard, 1983; Penke, Weyerts, Gross, Zander, Münte, & Clashen, 1997). In addition, it has been shown to be correlated with the cost of working memory, suggesting that LAN reflects working memory as well as morphosyntactic processing (e.g., King & Kutas, 1995; Kluender & Kutas, 1993). The time window from 300 to 500 ms of LAN and N400 was labeled Phase 2 for the integration of semantic and morphosyntactic information in Friederici (2002).

3.2.2.3 P600

P600 is a positive component that peaks approximately 600 ms after the stimulus and appears across the central to parietal regions of both hemispheres. P600 has also been designated as a Syntactic Positive Shift (SPS) by Hagoort, Brown, and Groothusen (1993) because this positive component is shifted from a negative component, LAN, in response to different kinds of sentences with syntactic natures. When P600 occurs simultaneously with the negative component, (E)LAN, it is considered biphasic.

As the violations of phrase structure and subjacency elicited P600 in Neville et al. (1991), P600 has been observed in response to syntactic violations such as phrase structure violation (e.g., Hagoort, Brown, & Groothusen, 1993; Osterhout & Holcomb, 1992) and empty category principle violation (e.g., McKinnon & Osterhout, 1996). In addition to syntactic violations, P600 has been also observed in response to morphological violations similar to LAN: number disagreement (e.g., Coulson et al., 1998; Hagoort et al., 1993, Münte et al., 1997; Osterhout & Mobley, 1995); gender violation (e.g., Barber & Carreiras, 2005; Gunter et al., 2000; Osterhout & Mobley, 1995; Wicha, Moreno, & Kutas, 2004); verbal inflection violation (e.g., Friederici et al., 1993); and Case making violation (e.g., Coulson et al., 1998). Apart from the violation paradigm, P600 has been observed for garden-path sentences which require reanalysis and repair of a given sentence (e.g., Osterhout, Holcomb, & Swinney, 1994). Others argue that P600 reflects a difficulty in syntactic integration (e.g., Kann, Harris, Gibson, & Holcomb, 2000). Taken together, P600 has been regarded as an indicator of controlled reprocessing in response to morphosyntactic violations, that of reanalysis and repair processing for garden-path sentences, and that of syntactic integration processing for the complex sentences. The time window ±600 ms of P600 was labeled Phase 3 for the processes of reanalysis and repair in Friederici (2002). In the recent studies, P600 has observed in response to the semantic anomalies (e.g., Kuperberg, 2007; van Herten, Kolk, & Chwilla, 2005) along with N400, which calls the linguistic function of P600 into question.

3.3 ERP Studies in Bilinguals and L2 Learners

Section 3.3 reviews ERPs studies of L2 semantic processing and L2 morphosyntactic processing in bilinguals and L2 learners in terms of the effects of the age of L2 acquisition, L2 proficiency level, and L1 transfer.

3.3.1 L2 Semantic Processing

N400, which has been regarded as the indicator of semantic processing in native speakers, has been also used as the indicator of L2 semantic processing in bilinguals and L2 learners.

Hahne and Friederici (2001) and Hahne (2001) investigated L2 semantic processing with L2 syntactic processing in L2 learners using ERPs. German stimuli were auditorily presented to participants and consisted of semantic expectations (e.g., Die Tür wurde *geschlossen* "The door was being closed"/*Der Ozean wurde *geschlossen* "*The ocean was being *closed*") and syntactic sentences in both of the studies, and a combination of the two in Hahne and Friederici (2001). Participants in their studies were Japanese L2 learners of German who acquired German at around the age of 10 in Hahne and Friederici (2001), and Russian L2 learners of German who acquired German at around the age of 18 in Hahne (2001). The German proficiency level in the Japanese L2 learners in Hahne and Friederici (2001) was lower than the

Russian L2 learners in Hahne (2001). German native speakers also participated in both of the studies as a control group. In response to the semantic anomalies, both of the studies observed a centro-parietal N400 in the L2 learners as well as in the German native speakers. Hahne and Friederici (2001) reported no significant difference in either the latency or amplitude of N400 between the German native speakers and the Japanese L2 learners, whereas Hahne (2001) reported N400 with longer peak latency and reduced amplitude in the Russian L2 learners relative to the German native speakers.

Hahne and Friederici (2001) and Hahne (2001) suggest that N400 was elicited in response to the semantic anomalies in the L2 learners as well as in the native speakers, although there might be a quantitative difference (the delayed and reduced N400) between the native speakers and the L2 learners in semantic processing, and the latency and/or the amplitude of N400 would be modulated by the effect of the age of L2 acquisition and/or L2 proficiency level (Hahne, 2001).

As the two studies show, L2 semantic processing in bilinguals and L2 learners has been examined in particular in reference to the effects of the age of L2 acquisition and L2 proficiency level.

3.3.1.1 The Effect of the Age of L2 Acquisition on L2 Semantic Processing

Ardal, Donald, Muter, Muldrew, and Luce (1990) was the first ERP study of L2 semantic processing, comparing ERP results in English monolinguals to those in highly fluent bilinguals (L1 French/L2 English). In this study, half of the bilinguals acquired English prior to the age of 11, and the others acquired English during or after adolescence. In the experiment, stimuli visually presented in English and in French were based on Kutas and Hillyard (1980). The results showed that N400 and an accompanying frontal negativity were elicited in response to the strong semantic mismatches in English in the monolinguals and to those on both English and French in the bilinguals. The latency of N400 was the shortest in the monolinguals, the next for the L1 of the bilinguals, and the longest for the L2 of the bilinguals. In addition, the amplitude of frontal negativity was reduced in the bilinguals who use the L2 less frequently. The authors reported that the age of L2 acquisition did not influence either the latency or amplitude of N400, or either those of the frontal negativity. The results suggest that L2 semantic processing was less automatic than L1, and therefore the bilinguals processed L2 semantic information more slowly than L1.

Weber-Fox and Neville (1996) followed this line of study. In their study, Chinese L2 learners of English were divided into five groups based on the age of L2 acquisition: 1–3, 4–6, 7–10, 11–13, and after 16 years of age. English stimuli consisted of semantic expectations and syntactic sentences associated with phrase structure and specificity were visually presented, which were used in Neville et al. (1991). The ERP results in Chinese L2 learners were compared with those in English native speakers in Neville et al. (1991) because the methods including the stimuli in their study were the same as those in the Neville et al. (1991) study. The results for the semantic expectations showed that N400 was elicited in response to the semantic anomalies in the Chinese L2 learners as well as in the English native speakers, but N400 was delayed in the > 11 groups, suggesting slight slowing in L2 semantic processing in the late L2 learners. It is noteworthy, however, that the age of L2 acquisition and the length of L2 experience of the Chinese L2 learners in this study were in inverse portion to the age of L2 acquisition, which does not strongly suggest the critical period for L2 semantic processing.

3.3.1.2 The Effect of L2 Proficiency Level on L2 Semantic Processing

Tatsuta, Fukuda, and Tomita (2001) and Tomita, Fukuda, and Tatsuta (2003) tried to confirm whether the difference in the English proficiency level would extend to that in English semantic processing indexed by N400 in late JLEs. In Tatsuta et al. (2001), the JLEs were divided into groups with higher or lower English proficiency as assessed by English assessments. Their age of English acquisition was controlled to be equal between the two groups: All of the JLEs started learning English in a classroom setting when they entered junior high school, at the age of 12 to 13. English native speakers also participated as a control group. English stimuli were visually presented and involved semantic expectations, which were based on those in Neville et al. (1991) (e.g., Mike listens to Frank's *speech*/**orange* about politics). The results showed that N400 was elicited in both of the JLE groups as well as in the English native speakers in response to the semantic anomalies: No group effect was observed on either the latency or amplitude of N400.

N400 in response to the semantic anomalies in late JLEs at different English proficiency levels was also reported by Ojima, Nakata, and Kakigi (2005). In that study, late JLEs were divided into groups with high or intermediate English proficiency, and English native speakers also participated as a control group. English stimuli visually presented were concerned with semantic expectations (e.g., The house has ten *rooms*/**cities* in total) and subject-verb agreement. The results for the semantic expectations showed that N400 was elicited in both of the JLE groups as well as in the English native speakers in response to the semantic anomalies. Although there was no group effect on the amplitude of N400, the latency of N400 was significantly different at the left hemisphere: the shortest in the English native speakers, the next in the high group, and the longest in the intermediate group. The results suggest the effect of L2 proficiency level on L2 semantic processing, and a quantitative difference in semantic processing between native speakers and L2 learners.

3.3.1.3 Summary of L2 Semantic Processing

Before changing the topic to L2 morphosyntactic processing, let us summarize L2 semantic processing in bilinguals and L2 learners here. As described in section 3.3.1, N400 is consistently elicited in response to the semantic anomalies in bilinguals and L2 learners as well as in native speakers. Some studies have reported that L2 semantic processing would be impervious to the age of L2 acquisition (Ardal, Donald, Muter, Muldrew, & Luce, 1990; Hahne & Friederici, 2001) or to L2 proficiency level (Hahne & Friederici, 2001; Tatsuta, Fukuda, & Tomita, 2001). Others have reported a delayed N400 in bilinguals and L2 learners who acquired L2 after the age of 11 (Weber-Fox & Neville, 1996) or the age of 18 (Hahne, 2001), in those who with lower L2 proficiency (Ojima, Nakata, & Kakigi, 2005), and in response to the less fluent language and a reduced amplitude of an accompanying frontal negativity in those who use the L2 less frequently (Ardal et al., 1990). These observations of the delayed and the reduced N400 and the reduced frontal negativity relative to native speakers in response to the semantic anomalies suggest a quantitative difference in N400-indexed semantic processing between native speakers and bilinguals/L2 learners.

3.3.2 L2 Morphosyntactic Processing

As well as N400 for L2 semantic processing in bilinguals and L2 learners, ELAN, LAN, and P600, which are assumed to be the indicators of morphosyntactic processing in native speakers, have been also used as the indicators of L2 morphosyntactic processing in bilinguals and L2 learners.

Hahne and Friederici (2001) and Hahne (2001) mentioned in section 3.3.1 investigated L2 syntactic processing as well as L2 semantic processing in L2 learners. The two studies auditorily presented the condition of phrase structure containing prepositional phrases (PPs) in German. The structure is present in German and Russian (e.g., Die Tür wurde *geschlossen* "The door was being *closed*"/*Das Geschäft wurde am *geschlossen* "*The shop was being on *closed*"), but is not present in Japanese.

In response to the violations of phrase structure, an early anterior negativity and P600 were elicited in German native speakers in both of the studies. The results in Hahne and Friederici (2001) showed no component in Japanese L2 learners of German in Hahne and Friederici (2001). Those in Hahne (2001), on the other hand, showed no early anterior negativity and P600 with delayed peak onset were elicited in Russian L2 learners of German. These results suggest that syntactic processing might differ between the German native speakers and the L2 learners if the L2 learners acquired their L2 later in life, e.g., by the age of 10 (Hahne & Friederici, 2001) or the age of 18 (Hahne, 2001). Importantly, L2 proficiency level and L1 were different between the two studies: The L2 proficiency level in Hahne and Friederici (2001) was lower than that in Hahne (2001), and the L1 in Friederici and Hahne (2001) was Japanese, but Russian in Hahne (2001). These differences might be crucial for the appearance of P600 because P600 was elicited only in Hahne (2001), where L2 learners had a higher L2 proficiency, and their L1 Russian exhibits phrase structure containing PPs like L2 German.

As the two studies show, L2 morphosyntactic processing in bilinguals and L2 learners has been examined in particular in reference to the effects of the age of L2 acquisition, L2 proficiency level, and L1 transfer.

3.3.2.1 The Effect of the Age of L2 Acquisition on L2 Morphosyntactic Processing

Weber-Fox and Neville (1996) was the first ERP study of L2 syntactic processing, which explored the critical period effect on L2 syntactic processing. As mentioned in section 3.3.1.1, ERP results for the conditions of phrase structure and specificity with semantic expectations in the Chinese L2 learners of English in this study were compared with those in the English native speakers in Neville et al. (1991). Table 3.1 below shows a summary of the ERP results in the two studies.

As mentioned earlier, N400 in response to the semantic anomalies was consistently elicited in all of the Chinese L2 learners regardless of their age of L2 acquisition as well as in the English native speakers, although N400 was delayed in the > 11 groups. The results for L2 syntactic processing, however, were not consistent in the Chinese L2 learners compared to those for L2 semantic processing. Firstly, in response to the violations of phrase structure, N125, a later sustained left anterior negativity from

300 to 500 ms after the stimulus, and P600 were elicited in the English native speakers. In the results of the Chinese L2 learners, N125 was elicited in none of the groups. The later sustained left anterior negativity similar to the English native speakers was elicited only in the 1–3 group. This later sustained negativity, on the other hand, was left-lateralized in the 4–10 groups, and was not elicited in the > 11 groups. As for P600 elicited in the English native speakers, P600 in the < 10 groups, a delayed positivity beginning at 700 ms after the stimulus in the 11–13 group, and no P600 in the > 16 group were confirmed. The authors interpreted the results for P600 as indicating that "an attempt to recover the meaning of the sentence was slower in these later learning groups and would have been detected at a later latency in the ERP epoch" (Weber-Fox & Neville, 1996, p. 250). Secondly, in response to the violations of specificity, N125 and a later sustained left anterior negativity from 300 to 500 ms after the stimulus were elicited in the English native speakers. Although the two components were elicited in the 4–10 groups, only the later sustained left anterior negativity was elicited in the 1–3 group, which "is not clear how to interpret" (Weber-Fox & Neville, 1996, p. 251). In the 11–13 group, a bilateral early negativity (N125) and a reduced later sustained left anterior negativity were elicited, but neither N125 nor the later sustained left anterior negativity was elicited in the > 16 group, which suggest "that, similar to phrase structure processing, with increased delays in language exposure there is reduced left hemisphere specialization, and possibly greater right hemisphere involvement" (Weber-Fox & Neville, 1996, p. 251).

To summarize, the results in this study suggest that the effect of the age of L2 acquisition led to quantitative differences between the English native speakers and the L2 learners in the < 13 groups in the later sustained left anterior negativity from 300 to 500 ms after the stimulus (LAN) (wider and reduced in the Chinese L2 learners as later exposed to L2) and P600 (delayed in the Chinese L2 learners as later exposed to L2). No component was elicited in the > 16 group in response to either the violations of phrase structure or specificity, suggesting a qualitative difference in syntactic processing between the English native speakers and the late Chinese L2 learners in the > 16 group. In conclusion, Weber-Fox and Neville (1996) argue that the results are consistent with the idea that the development of neural systems associated with language processing is constrained by the maturation changes. It is noteworthy again, however, that the age of L2 acquisition and the length of L2 experience in the Chinese L2 learners in this study were in inverse portion to the age of L2 acquisition, which does not strongly suggest the critical period for L2 syntactic processing.

Table 3.1

Summary of the ERP Results in English Native Speakers (Neville, Nicol, Barss, Forster, & Garrett, 1991) and Chinese L2 Learners of English (Weber-Fox & Neville, 1996): The Effect of the Age of L2 Acquisition

	Neville et al. (1990)	Weber-Fox & Neville (1996) Age of L2 acquisition				
Violation	English native speakers	1–3 years old	4–6 years old	7–10 years old	11–13 years old	> 16 years old
Semantic anomalies	N400	N400	N400	N400	Delayed N400	Delayed N400
Phrase structure	N125 Later sustained left anterior negativity from 300 to 500 ms P600	Later sustained left anterior negativity from 300 to 500 ms P600	Later sustained left-lateralized negativity from 300 to 500 ms P600	Later sustained left-lateralized negativity from 300 to 500 ms P600	Delayed positivity	N/A
Specificity	N125 Later sustained left anterior negativity from 300 to 500 ms	Later sustained left anterior negativity from 300 to 500 ms	N125 Later sustained left anterior negativity from 300 to 500 ms	N125 Later sustained left anterior negativity from 300 to 500 ms	Bilateral early negativity Reduced later sustained left anterior negativity from 300 to 500 ms	N/A

Note. N/A = Not Applicable.

3.3.2.2 The Effect of L2 Proficiency Level on L2 Morphosyntactic Processing

Ojima et al. (2005) mentioned in section 3.3.1.2 and Rossi, Gugler, Friederici, and Hahne (2006) examined the effect of L2 proficiency level on L2 morphosyntactic processing of subject-verb agreement in late L2 learners. Table 3.2 shows summary of the ERP results in the two studies.

In Ojima et al. (2005), English stimuli involved the conditions of subject-verb agreement (e.g., Turtles *move*/**moves* slowly) and semantic expectations were visually presented to late JLEs in groups with high or intermediate English proficiency and to English native speakers. The violations of subject-verb agreement elicited both LAN and P600 in the English native speakers, only LAN in the high group, and neither LAN nor P600 in the intermediate group, suggesting that P600-indexed morphosyntactic processing indicates a qualitative difference between the English native speakers and the JLEs. The authors have argued against the critical period, which claims of fundamental difference between post childhood L2 learning and childhood L1 learning, because of evidence that L2 morphosyntactic processing in the late JLEs was able to get close to the native-like neural responses with high L2 proficiency as shown by the appearance of LAN elicited in the high group as well as in the English native speakers. In addition to the effect of L2 proficiency level, the effect of L1 transfer on L2 morphosyntactic processing was confirmed because linguistic features that require subject-verb agreement in English are not present in Japanese.

In Rossi et al. (2006), either Italian or German simple active sentences including the conditions of word category (e.g., Italian: Il signore nel bar *beve*/**beve* un caffe "The man in-the bar *drinks*/*in-the *drinks* a coffee," German: Der Junge im Kindergarten *singt*/*im *singt* ein Lied "The boy in-the kindergarten *sings*/*in-the *sings* a song"), subject-verb agreement (e.g., Italian: Il signore nel bar *beve*/**bevo* un caffe "The man in-the bar *drinks*/**drink* a coffee," German: Der Junge im Kindergarten *singt*/**singest* ein Lied "The boy in-the kindergarten *sings*/**sing* a song"), and a combination of the two (e.g., Italian: Il signore nel bar *beve*/*nel *bevo* un caffe “The man in-the bar *drinks*/*in-the *drink* a coffee,” German: Der Junge im Kindergarten *singt*/*im *singst* ein Lied “The boy in-the kindergarten *sings*/*in-the *sing* a song”) were auditorily presented to Italian L2 learners of German and German L2 learners of Italian in their L2, and Italian and German native speakers in a control group in their L1. The L2 learners were divided into groups with high or low L2 proficiency, and all of the L2 learners were exposed to their L2 after the age of 11. In the results of the violations of subject-verb agreement, both LAN and P600 were elicited in the control and high groups, whereas only P600 with delayed onset and reduced amplitude relative to the high group was elicited in the low group. The results suggest that there was no qualitative or quantitative difference in morphosyntactic processing between the native speakers and the late L2 learners once the L2 learners have reached a high L2 proficiency level.

To sum up, P600 was consistently elicited in the late L2 groups as well as in the native speakers in Rossi et al. (2006), whereas P600 was never elicited in the late L2 learners in Ojima et al. (2005). The two studies, however, reached the same conclusion for L2 morphosyntactic processing in the late L2 learners: The late L2 learners were in fact able to get close to the native-like neural responses with high L2 proficiency as shown by the appearance of LAN in the higher L2 proficiency group as well as in the native speakers.

Table 3.2

Summary of the ERP Results in Late L2 Learners in Ojima, Nakata, and Kakigi (2005) and Rossi, Gugler, Friederici, and Hahne (2006): The Effect of L2 Proficiency Level

		Ojima et al. (2005)	Rossi et al. (2006)
	(Modality)	(Visual)	(Auditory)
Group	L1/L2	Japanese/English	Italian/German, German/Italian
Native speakers		LAN	LAN
		P600	P600
Higher L2 proficiency		LAN	LAN
			P600
Lower L2 proficiency		N/A	Delayed and reduced P600
			(relative to the higher L2 proficiency group)

Note. N/A = Not Applicable.

3.3.2.3 The Effect of L1 Transfer on L2 Morphosyntactic Processing

Sabourin (2003) and Tokowicz and MacWhinney (2005) examined the effect of L1 transfer on L2 morphosyntactic processing in late L2 learners. Table 3.3 shows a summary of the ERP results in the two studies.

In Sabourin (2003), Dutch stimuli including the conditions of finiteness (e.g., Ik heb in Groningen *gewoond*/**wonen* "I have *lived*/*to *live* in Groningen"), subject-verb agreement (e.g., Wij$_{\text{plural}}$ *praten*$_{\textit{plural}}$/**praat*$_{\textit{singular}}$ vaak over dat sprookje "We *talk*/**talks* often about that fairy tale"), and gender agreement (e.g., Het$_{\text{neuter}}$/*De$_{\text{common}}$ kleine *kind*$_{\textit{neute}}$ probeerde voor het eerst te lopen "The$_{\text{neuter/*common}}$ small *child*$_{\textit{neuter}}$ tried to walk for the first time") were visually presented to late German, English, or Romance L2 learners of Dutch and Dutch native speakers in a control group. The author analyzed the linguistic differences among the L2 learners' L2 (Dutch) and L1 (German, English, Romance): Dutch, German, and Romance have a gender feature, English does not have the feature, and the representation system of gender agreement in Romance is different from Dutch and German. All of the L2s and L1s of the L2 learners, on the other hand, have the features associated with finiteness and subject-verb agreement, and also their representation systems are the same across the four languages. In the results, P600 was elicited in response to the violations of finiteness in all of the L2 groups as well as in the Dutch native speakers. In addition, in response to the violations of subject-verb agreement, P600 was elicited in all of the L2 groups as well as in the Dutch native speakers, but the distribution of P600 was less widely in the English and the Romance groups. The most distinctive result was observed in response to the violations of gender agreement: P600 in the German group as well as in the Dutch native speakers, no P600 in either the English or Romance groups. Based on these results, it is suggested that the linguistic systems which are present in both the L2 and the L1 (i.e., finiteness and subject-verb agreement) were processed similarly in the late L2 learners and the Dutch native speakers as shown by the appearance of P600 in all of the L2 groups as well as in the Dutch native speakers. The linguistic system which is unique to L2 or L1/L2 different representation systems (i.e., gender agreement), however, tended to be processed in the late L2 learners qualitatively differently from the Dutch native speakers as shown by the absence of P600 in both the English and Romance groups.

P600 in response to the violations of L1/L2 similar constructions in L2 morphosyntactic processing in late L2 learners was also reported by Tokowicz and MacWhinney (2005). In this study, participants were late English L2 learners of Spanish who enrolled in the first four semesters of Spanish classes in a university. The Spanish stimuli visually presented involved the conditions of the auxiliary system (e.g., Su abuela *cocina*/**cocinando* muy bien "His grandmother *cooks*/**cooking* very well"), which is formed similarly in Spanish and English, determiner gender agreement (e.g., Ellos fueron a nua$_{\text{feminin}}$/*un$_{\text{masculine}}$ *fiesta*$_{\textit{feminine}}$ "They went to a *party*"), which is formed differently in Spanish from English, and determiner number agreement (Los$_{\text{plural}}$/*El$_{\text{singularl}}$ *ninos*$_{\textit{plural}}$ estan jugando "The *boys* are playing"), which is formed in Spanish but not in English. In the results, P600 was elicited in response to the violations of the auxiliary system and determiner number agreement, but not in response to the violations of determiner gender agreement in the English L2 learners. The results suggest that the L2 learners at early stages of L2 learning were sensitive to the violations of L1/L2 similar (i.e., auxiliary system) and different (i.e., determiner gender agreement) representation constructions, but were not sensitive to the violations of L2 unique (i.e., determiner number agreement) constructions.

Together with the ERP results in the two studies, they obtained the same results for L2 morphosyntactic processing in the late L2 learners from the viewpoint of the effect of L1 transfer: P600 in response to the violations of L1/L2 similar systems, but no P600 in response to the violations of the L2 unique system. In response to the violations of L1/L2 different representation systems, the two studies, however, obtained different results: no P600 in Sabourin (2003), but P600 in Tokowicz and MacWhinney (2005).

The results in Sabourin (2003) are consistent with the underlying predictions of the RDH mentioned in the previous chapter: Uninterpretable features that have not been selected during the critical period are no longer available, and consequently late L2 learners are not able to acquire the features. In the study, uninterpretable feature [gender] was crucial for the late L2 learners whose L1 does not have the feature and whose L1 exhibits a different representation system of the feature from the L2.

Table 3.3

Summary of the ERP Results in Late L2 Learners in Sabourin (2003) and Tokowicz and MacWhinney (2005): The Effect of L1 Transfer

		Sabourin (2003)	Tokowicz & MacWhinney (2005)
	(Modality)	(Visual)	(Visual)
Linguistic system	L1/L2	German, English, Romance/Dutch	English/Spanish
L1/L2 similar		P600: finiteness (German, English, Romance) P600: subject-verb agreement (German) Less wider P600: subject-verb agreement (English, Romance)	P600: auxiliary system (English)
L1/L2 different		N/A: gender agreement (Romance)	P600: determiner gender agreement (English)
L2 unique		N/A: gender agreement (English)	N/A: determiner number agreement (English)

Note. N/A = Not Applicable. ERP Component in response to: violations (L1(s) of the L2 learners who the component was elicited in).

3.3.2.4 Summary of L2 Morphosyntactic Processing

According to the ERP evidence, L2 morphosyntactic processing can be analyzed with generalized similarity and qualitative differences between native speakers and bilinguals/L2 learners.

First, similar to that in native speakers, P600 is elicited or quantitatively differently elicited in the latency or amplitude from native speakers in response to L2 morphosyntactic violations, even if they acquired their L2 after the age of 11 (Weber-Fox & Neville, 1996) or after the age of 18 (Hahne, 2001). This ERP component has also been found in those who have reached a high L2 proficiency level (Hahne, 2001; Rossi et al., 2006) and in response to violations that show linguistically similar (Hahne, 2001; Tokowicz & MacWhinney, 2005) and different (Tokowicz & MacWhinney, 2005) representation systems between L1 and L2.

Regarding qualitative differences, ELAN and LAN seem not to be elicited for L2 morphosyntactic violations, especially in those who acquired their L2 after the age of 11 (Weber-Fox and Neville, 1996), the age of 10 (Hahne & Friederici, 2001) or the age of 18 (Hahne, 2001) or in those who had not reached a high L2 proficiency level (Ojima et al., 2005; Rossi et al., 2006).

In Van Hell and Tokowicz (2010), there is inclusive discussion on the relationship between ERP components and factors that affect L2 processing. The authors pointed out that the absence and presence of ELAN or LAN in L2 learners depends on several factors, and they listed the following three factors:

- the type of syntactic structure and the expectancies L2 learners can generate with respect to violations of this structure;
- the degree of L1/L2 syntactic structure similarity;
- L2 proficiency level.

These factors are likely to be interrelated. For example, L2 learners may not be

> able to generate high expectations with regard to certain syntactic structures, because the L2 syntactic structures are dissimilar from the L1. This pattern, in turn, will change when L2 learners become more proficient, and progress from using L1 cues to using more native-like cues to comprehend the L2. (p. 70)

Those factors will affect the absence or appearance of P600 as well. In addition to the three factors, the age of L2 acquisition might also affect the absence and appearance of the ERP components (Hahne, 2001; Hahne & Friederici, 2001; Weber-Fox & Neville, 1996).

3.3.2.5 Developmental Stages of L2 Morphosyntactic Processing in Late L2 Learners

With respect to L2 morphosyntactic processing in late L2 learners, Steinhauer, White, and Drury (2009) specified the hypothetical developmental stages of processing in late L2 learners as indexed by ERP components with references to studies introduced in this chapter and some additional studies (Table 3.4).

According to the authors, the developmental stages are as follows: In the first stage, stage 1, no component is elicited in response to L2 morphosyntactic violations in late L2 learners with *novice* L2 proficiency, suggesting their indifferent perception between grammatical and ungrammatical sentences because novice L2 learners are familiar with the meaning of content words but do not have grammatical knowledge. In the next stage, stage 2, N400 or right-lateralized/posterior negativities are elicited in late L2 learners with *very low* L2 proficiency, suggesting the difficulties in lexical access and semantic integration processing of the content words that the L2 learners know as well as the unavailability of L2 morphosyntactic processing. This cognitive process is expected because the very low L2 learners might rely on explicit knowledge and compensatory strategies[4] in order to response to morphosyntactic violations, resulting not in syntactic but instead in N400-indexed semantic integration processing. The following stage, stage 3, is the stage for the beginning of grammaticalization or proceduralization in late L2 learners with *low* to *intermediate* L2 proficiency. In stage 3, delayed/reduced P600 is elicited in addition to N400 because low to intermediate L2 learners begin to analyze the structure of morphosyntactic violations. However, they still perform N400-indexed semantic integration processing in response to morphosyntactic violations instead of LAN-indexed the early automatic processing. This appearance of N400 in the stages 2 and 3 in response to morphosyntactic violations was confirmed by a longitudinal study, in which late L2 learners took classroom instruction for one month (Osterhout, McLaughlin, Pitkanen, Frenck-Mestre, & Molinaro, 2006), and is predicted by the declarative/procedural model proposed by Ullman (2001, 2005) (Steinhauer, White, & Drury, 2009). Once P600 is elicited, N400 can be diminished, which is observed in the following, stage 4. In stage 4, an earlier/larger P600 relative to stage 3 is expected in late L2 learners with *intermediate* L2 proficiency, suggesting that native-like mechanisms of late controlled morphosyntactic processing are induced because of the learners' attempt of performing reprocessing, reanalysis, repairs, and P600-indexed syntactic integration. Finally, a LAN-like negativity is elicited in stage 5 in late L2 learners with *intermediate* to *high*/*near native-like* L2 proficiency instead of N400. The negativity in stage 5 is a bilateral anterior negativity, but this is finally left-lateralized in stage 6, which is the final stage, in late L2 learners with *very high* to *native-like* L2 proficiency. In stage 6, the very high to native-like L2 learners are able to perform LAN-indexed native-like early automatic processing and P600-indexed late controlled

[4] Compensatory strategies are described by Poulisse (1990) as "processes operating on conceptual and linguistic knowledge representations, which are adopted by language users in the creation of alternative means of expression when linguistic shortcomings make it impossible for them to communicate their intended meaning in the preferred manner" (pp. 192–193). According to Poulisse (1990), compensatory strategies are divided into two archistrategies. One is conceptual archistrategies, in which L2 learners could refer to intended meaning by substituting the word for a related concept which shares some criteria properties such as *the place where the ships stop* for *harbor* (analytic) and *fruits* for *pineapple* (holistic). The other is linguistic archistrategies, in which L2 learners could compensate L2 words by their linguistic knowledge, such as *closing food* for *desert* (translation) and *ironize* for *iron* (morphological creativity).

morphosyntactic processing. Consequently, no differences are observed in this stage in the morphosyntactic processing between native speakers and late L2 learners.

To sum up, the expected sequence of the ERP component for L2 morphosyntactic processing in late L2 learners with higher L2 proficiency levels becomes is N400 → N400 + delayed/reduced P600 → earlier/larger P600 → anterior negativity + P600 → LAN + P600 with a quantitative difference across the stages (from delayed/reduced/wider component on the earlier stages to the native-like component in the later stages).

Table 3.4

Hypothetical Developmental Stages of L2 Morphosyntactic Processing in Late L2 Learners Indexed by ERP Components by Steinhauer, White, and Drury (2009)

Stage	L2 proficiency level	ERP components	Underlying cognitive processing
1	Novice	N/A	Indifferent perception between grammatical and ungrammatical sentences
2	Very low	N400 or right-lateralized/posterior negativities	Difficulties of lexical access and semantic integration processing of the content words that L2 learners know; no morphosyntactic processing
3	Low to Intermediate	possibly N400 delayed/reduced P600	Lexical and semantic processing Beginning of grammaticalization or proceduralization (beginning of late controlled morphosyntactic processing)
4	Intermediate	earlier/larger P600	Native-like mechanisms of late controlled morphosyntactic processing
5	Intermediate to High/Near native-like	bilateral anterior negativity P600	Near native-like early automatic processing Native-like late controlled morphosyntactic processing
6	Very high to Native-like	LAN P600	Native-like early automatic processing Native-like late controlled morphosyntactic processing

Note. N/A = Not Applicable.

3.4 Functional Magnetic Resonance Image Studies of L2 Processing in Bilinguals and L2 Learners

The fMRI results have advanced the understanding of the neural mechanisms underlying L2 processing and acquisition owing to its data with high-spatial resolution, in particular in the language-specific areas of the left frontal lobes called Broca's area (Brodmann Area [BA] 44/45), which functions link to speech production, and those of the left temporal lobes called Wernicke's area (BA 22), which functions in turn link to understanding of spoken and written languages.

Kim, Relkin, Lee, and Hirsch (1997) examined the activated areas in the brain in response to L1 and L2 in bilinguals in terms of the effect of the age of L2 acquisition using fMRI. Their participants were Turkish bilinguals (L1 Turkish/L2 English), who acquired English either in infancy (early bilinguals) or in early adulthood (the average of 11 years old) (late bilinguals). In the experiment, the bilinguals imaged what happened the previous day in either Turkish or English. The results showed a group effect only in Broca's area. In Broca's area, the activated areas in response to L1 and those in response to L2 were in common in the early bilinguals, but the activated areas in response to L1 were separated from those in response to L2 in the late bilinguals. In Wernicke's area, or no separated activated area was found in either of the group.

Dehaene et al. (1997) also reported activation differences in the brain between L1 and L2 processing using fMRI. The participants were French bilinguals (L1 French/L2 English), who acquired English after the age of seven at school and had moderate English proficiency. In the experiment, the bilinguals listened to a story in either French or English. The results indicated that while they were listening to the L1, Wernicke's area along the superior temporal gyrus was activated, whereas while listening to the L2 the temporal and frontal lobes in both hemispheres were activated with high variability, and sometimes the activated areas were restricted to the right hemisphere. The authors, thus, argue that L1 processing and acquisition takes place mainly in the left hemispheric cerebral networks, and the mechanisms of processing and acquisition are different between the L1 and L2.

Syntactic processing in bilinguals was investigated using fMRI by Kovelman, Baker, and Petitto (2008) with Spanish bilinguals (L1 Spanish/L2 English), who were exposed to English early in life and had high English proficiency. Stimuli visually presented to the bilinguals were in either English or French, which included two types of relative-clause sentences: object-subject sentence type (OS) (e.g., *The child spelled the juice that stained the rug*); and subject-object sentence type (SO) (e.g., *The juice that the child spilled stained the rug*). English monolinguals also participated in the study as a control group, and were presented the stimuli only in English. The authors assumed that English monolinguals prefer OS to SO, whereas Spanish monolinguals prefer SO to OS, and predicted that the preference difference would reveal different patterns of neural activity in the brain. In the results, English monolinguals showed an increased activation in Broca's area (BA 45) for SO (nonpreferred) processing than OS (preferred) processing in English as expected, whereas the activated areas were similar in the bilinguals regardless of the languages presented (English/Spanish) or the sentence types (SO/OS). Importantly, the bilinguals showed the greater increased activation in the areas than English monolinguals for English processing. The results suggest that syntactic processing between the monolinguals and the early bilinguals was different, apparently quantitatively different.

Waternburger, Heekeren, Abutalebi, Cappa, Villringer, and Perani (2003) investigated the effects of the age of L2 acquisition and L2 proficiency levels on neural correlates of grammaticality and semantic judgments on Italian and German sentences. Italian bilinguals (L1 Italian/L2 German) were divided into three groups based on their age of L2 acquisition and L2 proficiency level: early acquisition high proficiency (EAHP), late acquisition high proficiency (LAHP), and late acquisition low proficiency (LALP). Stimuli visually presented consisted of either the Italian or German grammatical conditions associated with number (e.g., *Der Hund$_{\text{singular}}$ *laufen$_{plural}$* über die Wiese "The dog$_{\text{singular}}$ *run$_{plural}$* over the meadow"), gender (e.g., Das$_{\text{neuter}}$ *Kalender$_{masculine}$* hängt an der Wand "The$_{\text{neuter}}$ *calendar$_{masculine}$* hangs at the wall"), and Case (e.g., I gatti$_{\text{plural}}$ *ama$_{singular}$* cacciare i topi "The cats$_{\text{plural}}$ *likes$_{singular}$* hunting the mice"), which are overtly marked in both Italian and German, and the semantic condition (e.g., *Das Reherschießt den *Jäger* "The deer shoots the *hunter*"). In the experiment, the bilinguals were asked to judge a presented sentence and comment as to whether the sentence was grammatically or semantically correct or not. The results in the LAHP group demonstrated the greater activations relative to the EAHP in the inferior frontal gyrus (BA 44 and 44/6) for the L2 grammaticality judgment, whereas no difference in the activated areas was observed for the L2 semantic judgment between the HP groups, suggesting the effect of the age of L2 acquisition only on the L2 grammaticality judgment. In contrast to the HP groups, the results in the LA groups demonstrated the differences in the activated areas for both the L2 grammaticality and L2 semantic judgments. The differences were in greater activation in the LAHP relative to the LALP in the left temporal parietal junction (BA22/23), the right lingual gurus (BA 18), and the right inferior parietal lobule (BA 40) for the L2 grammaticality judgment, and greater activation in the left middle frontal regions (BA 46) and the right fusiform gyrus (BA 37), and less activation in the left inferior frontal (BA 44/6) and the right middle frontal areas (BA 46/9) for the L2 semantic judgment. In the comparison of L1s, there was no group effect on either the grammaticality or semantic judgments. Waternburger et al. (2003) then reached conclusions that the L2 semantic judgment depended on the L2 proficiency level because the age of L2 acquisition did not have an effect on the L2 semantic judgment, and that the age of L2 acquisition in turn had impact mainly on the L2 grammaticality judgment compared to the L2 semantic judgment.

Yusa et al. (2011) investigated the role of instruction on English acquisition and processing in JLEs using fMRI. Japanese university students were divided into two groups. One was the instruction group, in which the participants received eight classes of instruction for English negative inversion (NI) (e.g., *Those students are never late for class → Never are those students late for class*) with only simple sentences after the first fMRI scanning. The other group is a non-instruction group, in which the participants did not receive the instruction. The participants in the two groups had no knowledge of NI at the time of the first fMRI scanning, and neither their age of learning English nor English proficiency level differs between them. This study of the acquisition and processing of NI by JLEs is assumed to able to answer the question of the accessibility to UG in English acquisition by JLEs because the rules of NI reflect the principle of structure dependency in UG, and Japanese does not exhibit the NI. The first fMRI scanning was conducted before the instruction, and the second scanning after the instruction for the instruction group. Stimuli visually presented phrase-by-phrase involved either *simple* sentences, for which the instruction group received the instruction, or *complex* sentences containing relative clauses (e.g., *Those students who are very smart are never silent in class → Never are those students who are very smart silent in class*), for which either group received the instruction. The results in the non-instruction group showed no significant activation differences in the brain between the first and second fMRI scanning regardless of the sentence types. Those in the instruction group, however, showed a significant activation difference in Broca's area between the two scannings: A significant activation decrease was found in response to the grammatical NI with simple sentences, and an increase was found in response to the complex sentences. These results suggested that L2 learners are able to acquire syntactic knowledge more than what they have learned in a classroom setting, and hence support the view that both nature (UG) and nurture (instruction) cooperate together in acquiring and processing the L2.

Although fMRI as well as ERP studies have obtained inconsistent results for L2 processing, especially for L2 morphosyntactic processing, it is suggested that L2 processing is quantitatively or qualitatively different from L1 processing, and that L2 processing might be modulated by many factors such as the age of L2 acquisition, L2 proficiency level, and L1 transfer. By controlling the factors that affect L2 acquisition and processing carefully, it will become possible to gain more insights into the neuronal mechanisms underlying L2 acquisition and processing.

The next chapter, chapter 4, presents the experiment using ERPs.

Chapter 4

Experiment

Chapter 4 presents the experiment using ERPs. The purpose of the present study is to investigate the neural mechanisms underlying English morphosyntactic processing in Case, Present (subject-verb agreement), and Past (past tense inflection) in JLEs in terms of the effects of the age of L2 acquisition (the age of learning English), L2 proficiency level (the English proficiency level), and L1 transfer.

4.1 Previous Studies

As already described in chapter 2, it is well known that even advanced or early L2 learners use verbal and nominal inflections variably or optionally under circumstances in which native speakers obligatorily use inflectional morphology (Franceschina, 2002; Hawkins & Chan, 1997; Hawkins & Hattori, 2006; Hawkins & Liszka, 2003; Haznedar & Schwartz, 1997; Ionin & Wexler, 2002; Lardiere, 1998a, 1998b, 2000, 2002; Prévost & White, 2000; Tsimpli, 2003).

Izumi, Uchimoto, and Ihara (2004) found in a corpus[1] study that the most frequent occurring errors in English by JLEs were omission of articles. The authors also reported that JLEs overused 3SG *-s* for 3rd-person plural-number subjects (e.g., They *play*/**plays* baseball together) more often than for 1st-person singular-number subjects (e.g., I *check*/**checks* out staff's schedule) and for 2nd-person singular-number subjects (e.g., You *seem*/**seems* like you are staying inside the sea).

Within the framework of the MP, a number of studies have focused on the variability of English inflectional morphology (e.g., 3SG *-s* and past tense *-ed*) by JLEs.

Wakabayashi (1997), using a self-paced word-by-word reading task, found no

[1] The National Institute of Information and Communications Technology (NICT) JLE Corpus, which is a two-million word corpus of JLEs.

group difference between intermediate and advanced JLEs in sensitivity to omission of 3SG -*s*. He, on the contrary, found a group difference in the sensitivity of overuse of 3SG -*s*: The advanced JLEs were sensitive to overuse of the 3SG -*s* regardless of the types of subject-verb disagreement (i.e., subject-verb disagreement in person and/or in number), whereas the intermediate JLEs were sensitive to overuse of the 3SG -*s* for the 2nd-person singular-number subjects (e.g., You *go*/**goes* to the pub) (subject-verb disagreement in person), but not for the 3rd-person plural-number subjects (e.g., Tom and Susan *like*/**likes* to go to the beach) (subject-verb disagreement in number). The author explained these findings by the difference of the features for subject-verb agreement: The intermediate JLEs might not have to learn intrinsic features such as [person] of NPs, which are specified by the lexical items before any operations are taking place, but have to learn optional features such as [number] of NPs, which are specified by the operations in numeration.

Using an oral translation task, Wakabayashi, Fukushima, and Maeyama (2006) reported that late intermediate JLEs tended to omit 3SG -*s* when they produce a sentence with an ADV intervening between the subject NP and the VP more frequently than the sentences without an ADV between them. Furthermore, the authors found that the JLEs tended to omit 3SG -*s* when a longer ADV (e.g., *sometimes* and *usually*), in the sense of the phonetic/orthographical distance, intervened the subject NP and the VP more than when a shorter ADV (e.g., *often* and *always*) intervened them. Based on these results, the authors maintained that the variability in the use of 3SG -*s* by the JLEs was due to the defective process of inserting the overt morphological forms to represent relevant syntactic features: The variability reflected performance factors which were associated with the linear phonetic/orthographical distance of a word (i.e., ADV) between the subject NP and the VP.

In a similar study, Wakabayashi and Yamazaki (2006) reported that production of 3SG -*s* by late intermediate JLEs was not influenced by a PP modifying the subject DP such as *with the blue eyes* in "The boy with the blue eyes *speak*/**speaks* good Japanese," but was influenced by an ADV between the subject DP and the VP such as *often* in "The student often *walk*/**walks* to school." Thereby, the authors argue that the results was caused by not a performance factor which was associated with the linear phonetic/orthographical distance of a word (i.e., ADV), which Wakabayashi et al. (2006) pointed out, but rather by the structural distance caused the results: *with the blue eyes* generates within the subject DP ([$_{DP}$ The boy *with the blue eyes*][$_{T}$ T][$_{VP}$ speaks good Japanese]), whereas *often* generates between the subject DP and the VP ([$_{DP}$ The student] [$_{T}$ T][$_{VP}$ *often* [$_{VP}$ walks to school]]). The results suggest that the JLEs were able to access to φ-features of T, which are overtly represented by Affix-Hopping[2] (e.g., Lasnik, 1999) at PF, and that structural distance between T and *v* caused the variability in the use of 3SG -*s* by the JLEs: The longer the distance was, the more 3SG -*s* the JLEs omitted.

Shibuya and Wakabayashi (2008), using the same task in Wakabayashi (1997), further investigated late intermediate JLE's sensitivity to subject-verb disagreement in a number of different types of subject NPs. The authors reported that the JLEs were sensitive to the disagreement in number when the plurality of the subject NP was characterized by a conjunction *and* (e.g., *Tim and Paul*) or a demonstrative *these* and a numerical quantifier (e.g., *These two secretaries*), but were not sensitive to it when the plurality of the subject NP was characterized by adding -*s* to a N in the subject NP (e.g., *The chefs*). The results suggest that the variability in the use of 3SG -*s* by the JLEs was not due to the difficulty of acquiring a subject-verb agreement system, but instead to the insensitivity to [number] of subject NPs.

Bannai (2008) investigated whether or not the results in Wakabayashi and Yamazaki (2006) could be confirmed in acquisition of past tense -*ed* as well as in that of 3SG -*s* by late intermediate JLEs, using a context-controlled oral translation task and a

[2] Lasnik (1999) suggested that lexical entries for verbs are in their bare forms and T and *v* are jointed at PF.

picture-aided oral production task. The author revealed that the JLEs produced past tense *-ed* highly accurately and constantly regardless of the existence of a PP or an ADV intervening between the subject NP and the VP in a sentence, whereas their production of 3SG *-s* was influenced by the disruption of adjacency between them. He accounted for the variability in the use of 3SG *-s* by the JLEs due to the lack of the features for subject-verb agreement (i.e., [person] and [number]) in Japanese, supporting the RDH, which predicts that uninterpretable features that have not been selected during the critical period are not available in late L2 acquisition.

As these studies show, English morphological variability by JLEs has been examined mostly by behavioral methods, and only a few studies have employed the neurophysiological methods such as ERPs to investigate the neural mechanisms underlying the variability by JLEs.

One of the ERP studies has been conducted by Ojima et al. (2005), which was already introduced in the previous chapter. The authors observed both LAN and P600 in response to the subject-verb disagreement in English native speakers, only LAN in late high JLEs, and neither LAN nor P600 in late intermediate JLEs. The results were assumed to be due to the lack of the features for subject-verb agreement in Japanese as well as the influence by the English proficiency level.

Wakabayashi, Fukuda, Bannai, and Asaoka (2007) also conducted an ERP experiment with late intermediate JLEs, and their results were consistent with those of a behavioral study conducted by Wakabayashi (1997): P600 was observed in response to the subject-verb disagreement in person (e.g., I *answer*/**answers* your letter) but P600 was not observed in response to the subject-verb disagreement in number (e.g., The teachers *answer*/**answers* our questions; Sam and Adam *answer*/**answers* our questions). The JLEs' insensitivity to subject-verb disagreement in number has been explained as follos: (1) the problem was not only due to the mapping from syntax to morphology, which is predicted by the MSIH, but also to [number] which is not present in Japanese in numeration; and (2) this was due to optional features (i.e., [number]), which are specified by operations in numeration, and therefore JLEs have to learn them.

So far the previous studies of English morphological variability by JLEs have been introduced, and there seems to be at least two limitations in the previous studies. One concerns methodologies in the previous studies. Some hypotheses suggested that L2 learners' morphological variability is related to performance factors such as communication pressure (Ionin & Wexler, 2002; Prévost & White, 2000). However, the elimination of the performance factors during speech production and experiments with behavioral methods is difficult. Furthermore, the causes of performance errors and the characteristics of the errors have not been refined in detail by such kinds of behavioral studies[3]. Using the ERP technique, which is employed in the present study, it is possible to minimalize performance errors and investigate the physiological and psychological status of cognitive processing for linguistic stimuli owing to its data with a high-temporal resolution. The other limitation is related to the small number of studies using neurophysiological methods. English is, to be exact, a foreign language rather than a L2 for JLEs living in Japan. Because of the too few neurophysiological studies of foreign language morphosyntactic processing or those of English morphosyntactic processing in JLEs, especially in early JLEs, who started learning English before they entered junior high school (the age from 11 to 12), the neural mechanisms underlying the processing have not been clarified so far. These two limitations motivated the present study to employ ERPs.

[3] Hawkins and Liszka (2003) mentioned methodological limitations in L2 studies using speech production, indicating that "performance on the morphology test would be a better reflection of the informants' competence, because it lessens such pressures, while performance in spontaneous oral use of English underrepresents informants' competence" (p. 31).

4.2 Factors for L2 Acquisition and Processing

L2 acquisition and processing could be affected by the various types of factors, which should be appropriately controlled in L2 studies depending on the purpose of the research.

Factors that affect L2 acquisition and processing are mostly divided into two categories (e.g., Ellis, 1997): (1) internal factors, which show the general properties of L2 learners such as intelligence, proficiency, language aptitude, age, learning style, and personality; and (2) external factors, which are affected by cultural and social influences such as motivation, learning strategies, quality of instruction, and experience of learning (acquiring) language. Among these factors, the present study picked up three factors to assess the effects on English morphosyntactic processing in JLEs: the age of L2 acquisition (the age of learning English), L2 proficiency level (the English proficiency level) as internal factors, and L1 transfer as an external factor.

Firstly, controlling the age of L2 acquisition is indispensable to assess the CPH, although the debate of the CPH and the accessibility to UG in reference to the CPH should not be directly based only on the effect of the age of L2 acquisition. Secondly, by means of controlling L2 proficiency level, initial and steady states and developmental stages of L2 acquisition and processing could be investigated: initial and steady states by L2 learners with elementary L2 proficiency and by those with advanced L2 proficiency, respectively, and developmental stages by comparing those with elementary, intermediate, and advanced L2 proficiency. In the present study, in order to assess the effect of the age of L2 acquisition, JLEs were divided into two groups, *Early* or *Late*, based on the age of learning English, and then each group was subdivided into two groups to assess the effect of L2 proficiency level, *High* or *Low* as assessed by an English proficiency test. Accordingly, the present study employed four JLE groups: Early-High (EH), Early-Low (EL), Late-High (LH), and Late-Low (LL). Lastly but crucially, concerning the third factor, L1 transfer, it is noteworthy that a number of linguistic differences and similarities between English and Japanese have been reported (e.g., Fukui, 1995a; Fukui & Sakai, 2003; Fukui & Takano, 1998; Sakai, 2000; Takano, 2004). Studies of L2 acquisition and processing in which materials are consisted of several types of linguistic differences and similarities between L1 and L2 could are believed to provide us with a deeper understanding of L2 acquisition and processing from comprehensive and multilateral viewpoints. Under this consideration, the present study used the following three conditions for materials: *Case*, *Present* (subject-verb agreement), and *Past* (past tense inflection). All of the conditions show the linguistic differences in the morphological representation system between English and Japanese. The detailed participants' information and the properties of each condition are described in the appropriate sections below.

As discussed in the previous chapters, the effects of the three factors on L2 acquisition and processing have been investigated by a number of studies within the framework of the MP. For example, all of the three factors, especially the age of L2 acquisition and L1 transfer, are crucial for the RDH because the hypothesis predicts that uninterpretable features that are not present in L1 and are not selected during the critical period should not be available, and consequently late L2 learners even with advanced L2 proficiency no longer fully acquire the features. The age of L2 acquisition and L2 proficiency level, by contrast, are not crucial for the MSIH because the hypothesis predicts that L2 learners are able to establish target-like syntactic representations based on their L1 regardless of their age of L2 acquisition or L2 proficiency level. The three factors, however, are critical to evaluate both of the hypotheses.

4.3 Linguistic Properties of the Materials

Because the present study examined the neural mechanisms underlying English morphosyntactic processing in Case, Present (subject-verb agreement), and Past (past tense inflection) in JLEs, it is necessary to analyze the linguistic properties of functional categories associated with the three conditions in both English and Japanese. Table 4.1 summarizes the comparisons of properties of functional categories associated with the three conditions in English and Japanese.

Table 4.1

Comparisons of Properties of Functional Categories Associated with the Materials in English and Japanese

Linguistic property	Language	Case	Present	Past
Formal features[a]	English	Uninterpretable Case feature [Case] of pronoun and determiner phrases[b]	Uninterpretable φ-features [person][number] of Tense, Interpretable tense feature [present] of Tense & Uninterpretable inflectional feature [Infl][c] of light verb	Interpretable tense feature [past] of Tense & Uninterpretable inflectional feature [Infl][c] of light verb
	Japanese	N/A[b]	N/A	Interpretable tense feature [past] of Tense
Morphological representations	English	Distinctive pronoun (e.g., nominative *I* and accusative *me*)	-*s* for regular thematic verbs	-*ed* for regular thematic verbs
	Japanese	Distinctive Case particle attached to the end of pronoun and noun (e.g., nominative -*ga* and accusative -*wo*)	N/A	-*ta*

Note. N/A = Not Applicable.
[a]functional features which are predominately representative for the morphological representations. [b] Wakabayashi (1997) and Wakabayashi, Fukuda, Bannai, and Asaoka (2007) suggested that, in accordance with Harada (1976), Japanese has [person] which exists in honorific expressions, but does not have [number] as a formal feature. The present study follows Fukui and Sakai's (2003) analysis that Japanese lacks both [person] and [number] for subject-verb agreement. [c] The dissertation uses [Infl], which represents [*u*Infl:] for uninterpretable inflectional feature in Adger (2003).

4.3.1 Case Condition

Case ([Case]) in the present study refers to structural Case, which is valued as a consequence of Agree (e.g., nominative if c-commanded by T and accusative if c-commanded by a transitive head). The structural Case differs from inherent case, which in turn is valued by virtue of its semantic function[4].

Fukui and Sakai (2003) maintain that Japanese NPs lack the uninterpretable Case feature [Case], which is supposed to be deleted as a consequence of Agree. Japanese, however, does not have to undergo the operation of Agree unlike English because the overt Case particles are available in the lexicon. How the explicit obligatory Case particles are overtly represented in Japanese was analyzed by an example in (1).

(1)	Watashi-wa (-ga)	Mizuki-no	imouto-ni	sono	omocha-wo	age-ta.
	(I-TOP (-NOM)	Mizuki-GEN	sister-DAT	the	toy-ACC	give-Past)

"I gave Mizuki's sister the toy."

What is directly recognized in (1) is the fact that Japanese Case particles are overtly represented at the end of PRNs and Ns: A topic participle (TOP) -*wa* (nominative particles [NOM] -*ga*) is attached to the end of the subject PRN *Watashi* "I," a genitive particle (GEN) -*no* is attached to the end of the N which works for prenominal modifier *Mizuki*, a dative particle (DAT) -*ni* is attached to the end of the indirect object N *imouto* "sister," and an accusative particle (ACC) -*wo* is attached to the end of the direct object N *omocha* "toy." Accordingly, Japanese PRNs and Ns have their Case particles attached to the end of them, resulting in no change of their morphological forms. On the other hand, English PRNs are valued by their Cases morphologically and change their forms, resulting in distinct Case forms (e.g., nominative *I* and

[4] By this argument, Fukui and Sakai (2003) accounted for the existence of scrambling as well as the nonexistence of agreement in Japan.

accusative *me*) as a consequence of Agree, and English Ns are not valued by the uninterpretable Case feature [Case] morphologically (e.g., *sister*, *toy*). Suppose that "[t]o the extent that the operation is made available by UG, it should be available even in Japanese" (Fukui & Sakai, 2003, p. 308), the properties of Case particles are expected to play similar roles to those of Agree which requires the uninterpretable Case feature [Case] in English.

4.3.2. Tense

To analyze linguistic properties associated with the Present and Past conditions, we introduced an analysis of the morphological representation system of tense (-*s* for the present tense and -*ed* for the past tense) on regular thematic Vs in English. Adger (2003) formulated a chain relationship between T and *v* for the representations of tense features as a consequence of Agree: T with the interpretable tense feature [tense] and *v* with the uninterpretable inflectional feature [*u*Infl:] is present on a chain (T, *v*) relationship under a c-command. The existence of [Infl:] of *v* could ensure that the tense features must be pronounced on the V if the given sentence has no auxiliaries. In the analysis, T checks the uninterpretable tense features of *v* within the c-command, and the spell out rule for the chain is formed by checking the tense features as follows:

(2) Pronouncing Past Rule (PTR)

In a chain (T[tense], *v*[*u*Infl: tense]), pronounce the tense features on *v* only if *v* is the head of T's sister.

(Adger, 2003: 192)

This analysis can be represented as (3), where a horizontal arrow → represents the application of Agree, and ~~strikeout~~ represents the feature deleted as a consequence.

(3) T[tense: present/past] … *v*[*u*Infl: tense]

→ T[tense: present/past] … *v*[~~*u*Infl~~: present/past]

↓

pronounced as -*s* for the present tense

-*ed* for the past tense

Similar to the analysis of Adger (2003), we next analyze the morphological representation systems for the Present and Past conditions in English and Japanese.

4.3.2.1 Present Condition

Kuroda (1998), Fukui (1995a), and Fukui and Sakai (2003) have suggested that Japanese lacks the features for subject-verb agreement[5]. In Fukui and Sakai (2003), it is stated that "[i]t is fairly clear that noun phrases in Japanese lack (interpretable) φ-features, which results in the non-existence of uninterpretable φ-features on T" (p. 368).

How subject-verb agreement is morphologically represented in English and Japanese was analyzed by (4) and (5), in which (4a) and (5a) are in English, and (4b) and (5b) are their Japanese counterparts.

(4) a. The boy *likes* movies with action.

b. Sono syounenn-wa akushon eiga-ga *suki-dea-ru*.

(The boy-TOP action movie-NOM *like-Present*)

[5] Wakabayashi (1997) and Wakabayashi, Fukuda, Bannai, and Asaoka (2007) suggested that, in accordance with Harada (1976), Japanese has [person] which exists in honorific expressions, but does not have [number] as a formal feature. The present study follows Fukui and Sakai's (2003) analysis that Japanese lacks both [person] and [number] for subject-verb agreement.

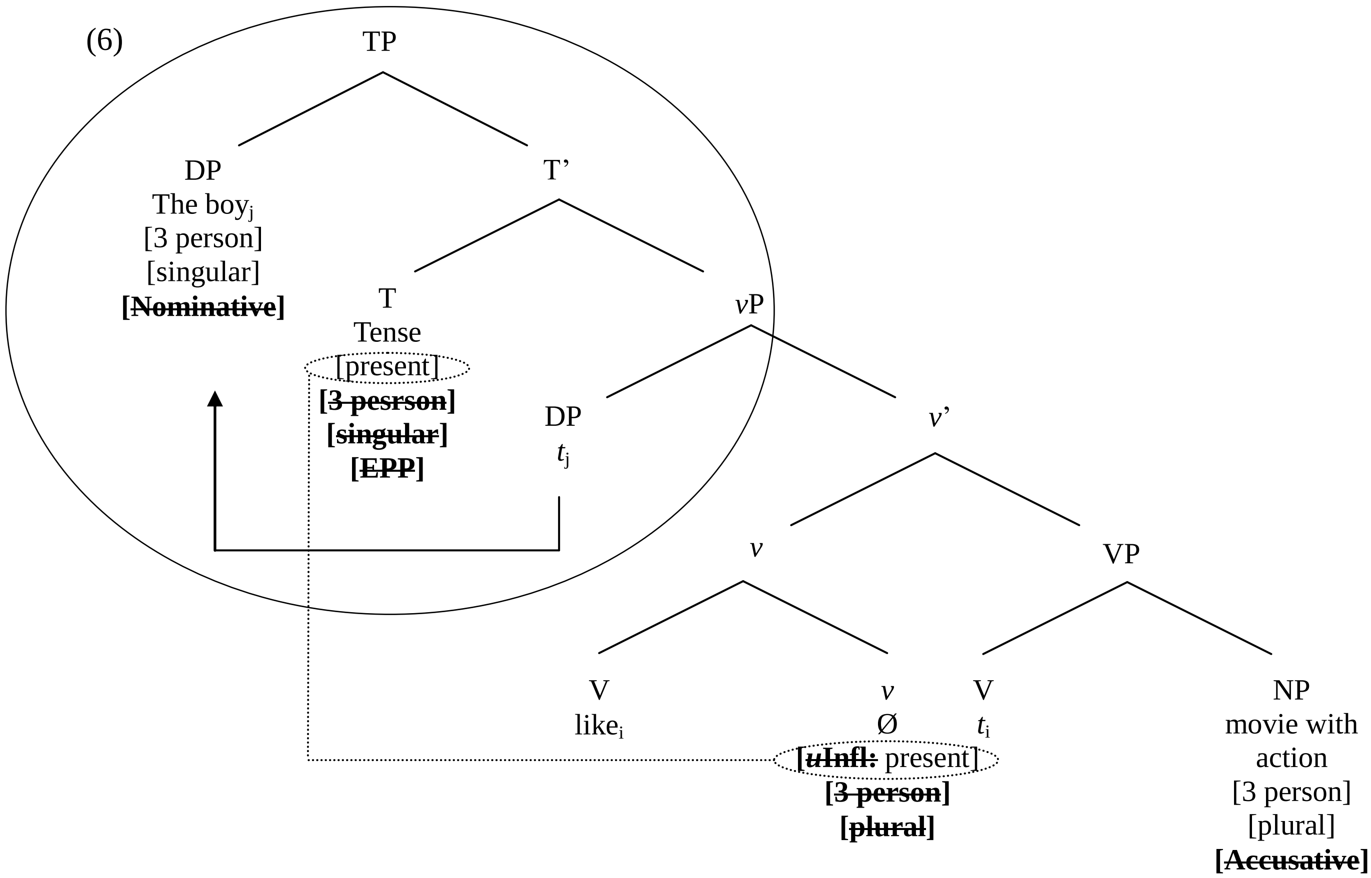
(5) a. I/You/Boys *like* movies with action.

b. Watashi/Anata/Shunenn-tachi-wa akushon eiga-ga *suki-dea-ru*.

(I/You/boy-Plural-TOP action movie-NOM *like-Present*)

In English, subject-verb agreement is overtly morphologically represented as -*s* in *likes* on a regular thematic V *like* for the 3rd-person singular-number subject DP *The boy* in (4a). To clarify, we analyzed the derivation of (4a). At a certain point of the derivation, (4a) has the structure in (6), in which uninterpretable features are in **bold** and ~~strikeout~~ indicates the features deleted as a consequence of Agree. At this point, the operation of Agree and Case assignment between *v* and NP *movies with action* have already taken place, and the V *like* has been raised from V of VP to V of *v*. Moreover, as illustrated in the circle in (6), uninterpretable φ-features [person][number] of T are checked by interpretable φ-features [3 person][singular] of DP *The boy*, and are then deleted. The DP *The boy,* which was originally generated in [Spec, *v*P], is moved to [Spec, TP] as indicated in (6) by the requirement of [EPP] of T. Thereby the DP *The boy* is valued as Nominative.

(6)



Interpretable tense feature [present] of T checks and values the uninterpretable inflectional feature [*u*Infl:] of *v*. Accordingly, subject-verb agreement is morphologically represented as -*s* on *v* for the 3rd-person singular-number subject DP *The boy* as a consequence of Agree between the interpretable tense feature [present] of T and the uninterpretable inflectional feature [*u*Infl:] of *v* as indicated by the dotted line in (6), which can be represented as (7).

(7) T[tense: present] … *v*[*u*Infl: tense]

→ T[tense: present] … *v*[~~*u*Infl~~: present]

↓

pronounced as -*s*

In case of (5a), however, interpretable φ-features of the subject (i.e., [Spec, TP]) are not [3 person][singular] but instead [1 person][singular] for PRN *I*, [2 person][singular or plural] for PRN *You*, or [3 person][plural] for DP *Boys*, and thus the uninterpretable φ-features [person][number] of *v* are not valued as [3 person][singular], resulting in no overt morphological representation of -*s*.

In contrast, subject-verb agreement in Japanese is not morphologically represented as shown *suki-dea-ru* in either (4b), in which the English counterpart (4a) exhibits the overt morphological representation -*s*, or (5a) for subject-verb agreement. This argument suggests that Japanese lacks the operation of Agree for subject-verb agreement

4.3.2.2 Past Condition

English regular thematic Vs exhibit the morphological representation *-ed* that is attached to the end of the regular thematic Vs for the past tense (Ogihara, 1999). Similarly, the Japanese -*ta*, which is attached to the end of Vs, can be regarded as the past morpheme[6] in contrast to -*ru*, which is the non-past morpheme (Ogihara, 1999).

Using this analysis, the past tense is morphologically represented in English and Japanese in examples (8) and (9), in which (8a) and (9a) are in English, and (8b) and (9b) are their Japanese counterparts.

(8) a. The boy *likes* movies with action.

b. Sono syounenn-wa akushon eiga-ga *suki-dea-ru*.

(The boy-TOP action movie-NOM *like-Present*)

[6] It is still remains controversial whether -ta is a tense morpheme or an aspect morpheme (Ogihara, 1999). Fukui and Sakai (2003) assumed Japanese Tense to be a "place holder" for tense morphemes, such as -*ru* (non-past) and -*ta* (past). Sadayoshi Ogawa suggested, in personal communication, that the difference between -*ru*/-*ta* does not reflect that of [–past]/[+past], but reflects that of [–perfect]/[+perfect] because -*ru* supplies both present and future-oriented interpretations.

(9) a. I/You/The boy/Many boys *liked* movies with action.

b. Watashi/Anata/Sono shyounenn/Ookuno shyounenn-tachi-wa akushon eiga-ga *suki-dat-ta*.

(I/You/The boy/Many boy-Plural-TOP action movie-NOM *like-Present*)

In English, past tense is overtly morphologically represented as *-ed* in *liked* on the regular thematic V *like* regardless of the person or number features of the subject PRNs and DP *I*/*You*/*The boy*/*Many boys* in (9a). Similarly, in Japanese, the past tense is overtly morphologically represented as *-ta*, in accordance with the past tense context that is represented by the temporal (past tense) ADVP *In those days*, which is shown as *suki-dat-ta* in (9b) in contrast to *-ru* in *suki-dea-ru* as the non-past morpheme in (8b).

The difference between English and Japanese is that the past morpheme *-ta* in Japanese is generated on T, which is similar to interpretable past tense feature [past] in English, and then attached to the end of V as a consequence of morphological merger. However, it is not an agreement marker like *-ed* on *v* in English (e.g., Fukui, 1995a; Takano, 2004; Sakai, 2000). According to Adger (2003)[7], in English, T carries interpretable tense feature [past], which checks and values the uninterpretable inflectional feature [*u*Infl:] of *v*, and then deletes the valued feature as a consequence of Agree: The past tense is morphologically represented as *-ed* on *v* as a consequence of Agree between the interpretable tense feature [past] of T and the uninterpretable inflectional feature [*u*Infl:] of *v*, which is the same as what the [person] and the [*u*Infl:] do in (6), and can be represented as (10).

[7] Hawkins (2005), which is introduced in chapter 2, also adopted the method of Adger (2003). Hawkins (2005) used the term [*u*tense] instead of [*u*Infl:], both of which refer to uninterpretable tense feature of *v*. See section 2.2.2.3 in chapter 2 for acquisition of tense features in English by L2 learners.

(10) T[tense: past] … v[*u*Infl: tense] → T[tense: past] … v[~~*u*Infl~~: past]

↓

pronounced as *-ed*

Japanese, however, does not have the uninterpretable inflectional feature [*u*Infl:] of v, resulting not in agreement between T and v (Hawkins, 2005), but instead in a morphological merger. The system of past tense marking in Japanese can be schematized as (11), where $\not\rightarrow$ represents no application of Agree.

(11) T[tense: past] … v[ ] $\not\rightarrow$ T[tense: past] … v[ ]

↓

pronounced as *-ta*

When we analize that the past tense is grammaticalized by the morphological representations as far as we can tell, it is expected that the properties of the past morpheme *-ta* in Japanese play a role similar to those of the past tense marker *-ed* in English (Fukui and Sakai, 2003) [8]. However, the past tense is morphologically represented by different features in the two languages. It is morphologically represented by the interpretable tense feature [past] of T, and then attached to the end of V as a consequence of morphological merger in Japanese, whereas the past tense is morphologically represented by the uninterpretable inflectional feature [*u*Infl:] of v as a consequence of Agree in English. The present study that used ERP components as indices examined whether the neural mechanisms underlying the processing of the surface morphological representations for the past tense were the same under the different morphological representation systems of the operation of Agree in English or morphological merger in Japanese. Distinct ERP components show evidence of the

[8] *-ta* in Japanese differs from *-ed* in English in more respects (Fukui, 1995a; Sakai, 2000; Takano, 2004), but the dissertation does not discuss them here in further detail.

qualitative differences in the underlying neural mechanisms.

4.4 Hypotheses

The expected ERP results were that a particular morphosyntactic processing ERP pattern, a biphasic ERP pattern with (E)LAN followed by P600, would be elicited in response to the violations of each condition in the ENS group. The ERP results in the four JLE groups (EH, EL, LH and LL), however, would be different from those in the ENS group, depending on the condition. The differences could be quantitative differences (the relative degree of latency or amplitude of the component) or qualitative differences (the presence or absence of the component or the distinct polity or topography). The possible ERP results were predicted in terms of the following three factors that might affect L2 acquisition and processing: the age of L2 acquisition, L2 proficiency level, and L1 transfer of the morphological representation system.

Firstly, Hypothesis 1 stated in terms of the effect of the age of L2 acquisition. Table 4.2 summarizes Hypotheses 1.

Hypothesis 1

> If the age of learning English has an effect on English morphosyntactic processing in JLEs, LAN followed by P600 will be elicited in the ENS and Early groups (EH and EL). Thus there will be qualitative differences in the ERP results between the three groups (ENS, EH, and EL) and the Late groups (LH and LL) in response to the violations of all conditions (Hahne, 2001; Hahne & Friederici, 2001; Weber-Fox & Neville, 1996).

Table 4.2

Expected ERP Components for Hypothesis 1

Group	Case	Present	Past
ENS	LAN followed by P600	LAN followed by P600	LAN followed by P600
EH	LAN followed by P600	LAN followed by P600	LAN followed by P600
EL	LAN followed by P600	LAN followed by P600	LAN followed by P600
LH	N/A	N/A	N/A
LL	N/A	N/A	N/A

Note. N/A = Not Applicable; ENS = the group of English native speakers; EH = Early-High; EL = Early-Low; LH = Late-High; LL = Late-Low.

The second hypothesis, Hypothesis 2, stated in terms of the effect of L2 proficiency level. Table 4.3 summarizes Hypotheses 2.

Hypothesis 2

If the English proficiency level has an effect on English morphosyntactic processing in JLEs, LAN followed by P600 will be elicited in the ENS and High groups (EH and LH). Thus there will be qualitative differences in the ERP results between the three groups (ENS, EH, and LH) and the Low groups (EL and LL) in response to the violations of all conditions (Hahne, 2001; Ojima, Nakata, & Kakigi, 2005; Rossi, Gugler, Friederici, & Hahne, 2006).

Table 4.3

Expected ERP Components for Hypothesis 2

Group	Case	Present	Past
ENS	LAN followed by P600	LAN followed by P600	LAN followed by P600
EH	LAN followed by P600	LAN followed by P600	LAN followed by P600
EL	N/A	N/A	N/A
LH	LAN followed by P600	LAN followed by P600	LAN followed by P600
LL	N/A	N/A	N/A

Before predicting the ERP results in terms of the third factor, L1 transfer, we summarized the comparisons of the properties of formal features associated with the three conditions in English and Japanese again. The linguistic property subject to the critical period predicted under the RDH is uninterpretable features that are not present in L1. The uninterpretable features, which are of concern to the present study, are [Case] of PRN for the Case condition, [person][number] of T and [Infl][9] of *v* that are associated with subject-verb agreement, and [Infl] of *v* that is associated with past tense inflection. Although all of the uninterpretable features are present in English, none of them are present in Japanese[10] (Hawkins, 2005; Kuroda, 1998; Fukui, 1995a; Fukui and Sakai, 2003; Takano, 2004). The overt morphological representations for Case and the past tense are present in both English and Japanese, whereas those for subject-verb agreement are present only in English. Even though the overt morphological representations are present for Case and the past tense in Japanese, the morphological representation systems in Japanese differs from those in English: In Japanese Case is morphologically represented by distinctive Case particle attached to the end of PRN and N, and the past tense is morphologically represented by the

[9] The dissertation uses [Infl] hereafter, which represents [*u*Infl:] for uninterpretable inflectional feature in Adger (2003).
[10] See footnote 4 in this chapter for the analysis of [person] in Japanese

interpretable tense feature [past] of T, and then attached to the end of V as a consequence of morphological merger, whereas they are morphologically represented by the uninterpretable features as a consequence of Agree in English. Because distinct ERP components show qualitative differences in the underlying neural mechanisms, Hypothesis 3 stated by focusing on the different morphological representation systems between the two languages. Table 4.4 summarizes Hypotheses 3.

Hypothesis 3

If L1 transfer of the morphological representation system has an effect on English morphosyntactic processing in JLEs, LAN followed by P600 will be elicited only in the ENS group. Thus there will be qualitative differences in the ERP results between the ENS and JLE groups in responses to the violations of each condition (Sabourin, 2003: Tokowicz &MacWhinney, 2005)

Table 4.4

Expected ERP Components for Hypothesis 3

Group	Case	Present	Past
ENS	LAN followed by P600	LAN followed by P600	LAN followed by P600
EH	N/A	N/A	N/A
EL	N/A	N/A	N/A
LH	N/A	N/A	N/A
LL	N/A	N/A	N/A

If any of the results in the JLE groups show ERP patterns identical with those in the ENS groups for all conditions, it follows that suggests that JLEs process the operation of Agree requiring the uninterpretable features, and the present study did not support the RDH. Although the RDH predicts that uninterpretable features that are not present in L1 and have not been selected during the critical period are subject to the critical period, none of the uninterpretable features associated with the three conditions are present in Japanese (Hawkins, 2005; Kuroda, 1998; Fukui, 1995a; Fukui and Sakai, 2003; Takano, 2004). However, if all of the results in the JLE groups show ERP patterns identical to those in the ENS group for the three conditions, the results could be interpreted in two ways. Firstly, the results were due to the explicit learning of the morphological representation system in English, that is, the operation of Agree. Secondly, it follows that the present study supported the full access to the UG position by claiming that L2 learners' grammar is constrained by UG. With respect to the MSIH, which refers to the full access to UG position and predicts the separation of syntactic representations from their phonological exponents in L2 learners regardless of the age of L2 acquisition or L2 proficiency level, the present study could not test the hypothesis completely because the present study employed visual presentations of the stimuli instead of auditory presentations.

4.5 Methods

4.5.1 Participants

To assess the effect of the age of learning English on English morphosyntactic processing in JLEs, the JLEs were divided into the following two groups: a group of JLEs who started learning English before they entered junior high school ($M_{age\ of\ learning\ English}$ = 5.60 years) (*Early* group[11]), and a group of JLEs who started learning after they entered junior high school ($M_{age\ of\ learning\ English}$ = 11.50 years) (*Late* group). Furthermore, to assess the effect of L2 proficiency level, each group was subdivided into a group with

[11] The Early groups belonged to an activity group in which they used English music or story CDs and learned the music and story by heart through listening. After memorization, they played dramas. The aims of the activity group were to acquire high English proficiency and self-expression ability through the activities. In the activity group, they basically did not receive any instructions on English grammar or English composition. They belonged to the activity group for an average of 14.10 years and engaged in the activity for an average of 131.85 min/week. In addition, they focused their attention on listening to CDs at their house for an average of 214.90 min/week.

high English proficiency (*High* group) or a group with low English proficiency (*Low* group): Proficiency was assessed using an English proficiency test, the *Oxford Placement Test: Quick Placement Test*[12] (University of Cambridge Local Examinations Syndicate [UCLES], 2001). Accordingly, there were four JLE groups: (1) the Early-High (EH) group, in which individuals started learning English before they entered junior high school and had high English proficiency; (2) the Early-Low (EL) group, in which individuals started learning English before they entered junior high school and had low English proficiency; (3) the Late-High (LH) group, in which individuals started learning English after they entered junior high school and had high English proficiency; and (4) the Late-Low (LL) group, in which individuals started learning English after they entered junior high school and had low English proficiency. All of the JLEs had regular chances to be exposed to English in daily life (e.g., taking English classes or using English as a profession). A summary of the characteristics for each JLE group is shown in Table 4.5.

Seventeen ENS (nine women, eight men, M_{age} = 25.71 years, age range: 19–30 years), who had temporarily stayed in Japan (M_{length} = 2.19 years, length range: 1 month–5 years), also participated in the experiment as a control group.

All participants had corrected visual acuity, no record of neurological or psychological disorders, and were right handed according to self-reports and as determined by handedness according to the methods of Luh, Rueckert, and Levy (1991). The ethics committee of Tokyo Metropolitan University approved all procedures and written informed consent was obtained from all of the participants.

[12] The *Quick Placement Test* is a written multiple-choice test that has 60 questions of English morphosyntax, and the score ranges from 0 to 60.

Table 4.5

Characteristics for Each JLE Group

		Age	*Oxford Placement Test*[a]	Length of stay[b]	
Group	*n* (women)	*M* (*SD*)	*M* (*SD*)	n^c	*M* (*SD*)
EH	23 (14)	22.63 (3.32)	45.62 (4.63)	20	6.12 (9.09)
EL	20 (12)	22.94 (4.73)	25.33 (4.54)	16	3.15 (4.49)
LH	23 (11)	24.45 (3.24)	46.74 (3.32)	19	10.14 (11.21)
LL	21 (9)	22.31 (4.55)	26.92 (5.23)	6	0.63 (2.29)

[a] The score in the High groups (EH, LH) ranged from 40 to 54, which indicates Upper intermediate and Advanced levels, and that in the Low groups (EH, LH) ranged from 18 to 39, which indicates Elementary and Lower intermediate levels. [b] The length of stay in an English speaking country (month). [c] The number of JLEs who had stayed there. All of them had stayed there after they entered junior high school.

A one-way analysis of variance (ANOVA) (Age × Proficiency) showed that the interaction of Age × Proficiency and the main effect of Age were not significant, $F(1, 83) = 0.09$, $p = .76$, $F(1, 85) = 1.77$, $p = .19$, respectively. The main effect of Proficiency, however, was significant, $F(1, 83) = 387.58$, $p < .001$. According to a chi-square test, the number of participants who had stayed in an English speaking country in LL was significantly smaller than that in the other groups, $\chi^2 (3, N = 87) = 16.17$, $p = .001$, and LH had stayed there significantly longer than the other JLE groups, $F(3, 83) = 6.38$, $p = .001$.

As well as being assessed by the *Oxford Placement Test* (UCLES, 2001), the JLE's English proficiency level was self-reported by two items on "Questions about Language and the Experiment" in Appendix A: (1) the recent levels or scores of English proficiency tests such as *EIKEN© (the Tett in Practical English Proficiency), TOEIC© (the Test of English for International Communication),* or *TOEFL PBT©* (*the Test of English as a Foreign Language Paper Based Test*) if they had taken the tests (Table 4.6); and (2) the self-rated English proficiency in listening, reading, speaking, and writing skills on a 5-point scale (0 = *scarcely*, 1 = *not sufficiently*, 2 = *sufficiently,* 3 =

well, and 4 = *perfectly*) (Figure 4.1 and Table 4.7).

Because of the small number of participants who had taken *TOEFL PBT* in the High groups, and those who had taken *TOEIC* and *TOEFL PBT* in the Low groups, the group effect examined was only between the High groups on the mean scores on *TOEIC*, using an independent samples *t* test: The mean scores on *TOEIC* did not differ between EH and LH.

Table 4.6

Distribution of TOEIC and TOEFL Scores

	TOEIC[a]			*TOEFL PBT*[b]		
Group	*n*[c]	*M* (*SD*)	Range	*n*[c]	*M* (*SD*)	Range
EH	14	897.31 (34.07)	840–965	5	591.0 (23.56)	560–620
EL	5	585.0 (106.77)	420–700	1	210	
LH	23	899.22 (34.76)	840–955	2	575.0 (7.07)	570–580
LL	5	412.0 (161.89)	260–625	0	0	

[a]The maximum score is 990. [b]The maximum score is 677. [c]The number of JLEs who had taken the test.

For the analysis of the self-rated English proficiency, a 4 × 4 (Skill [listening, reading, speaking, writing] × Group [EH, EL, LH, LL]) repeated measures ANOVA was conducted.

For both Skill, $F(3, 249) = 4.80$, $MSE = 0.35$, $p = .003$, and Group, $F(3, 83) = 8.37$, $MSE = 1.68$, $p < .001$, the main effects were significant, as well as the interaction of Skill × Group, $F(9, 249) = 3.13$, $MSE = 0.35$, $p = .001$. Then, the mean differences between and within groups were assessed with a Bonferroni multiple comparisons procedure with alpha levels of .05. The simple effect tests for Skill indicated that EH subjectively rated their English proficiency significantly higher in listening and speaking than in writing, $F(3, 66) = 7.34$, $MSE = 0.31$, $p = .001$, and LL rated significantly higher in reading than in speaking, $F(3, 60) = 4.23$, $MSE = 0.38$, $p = .008$, while EL and LH rated equally across the four skills. The simple effect tests for Group indicated significant group differences in rating their English proficiency depending on the skills: In listening, $F(3, 83) = 7.76$, $MSE = 0.72$, $p < .001$, LH rated higher than EL and LL, and EH rated higher than LL. In speaking, $F(3, 83) = 4.09$, $MSE = 0.73$, $p = .009$, LH rated higher than LL. In reading, $F(3, 83) = 7.13$, $MSE = 0.56$, $p < .001$, and writing, $F(3, 83) = 6.72$, $MSE = 0.71$, $p < .001$, LH rated higher than the other three groups.

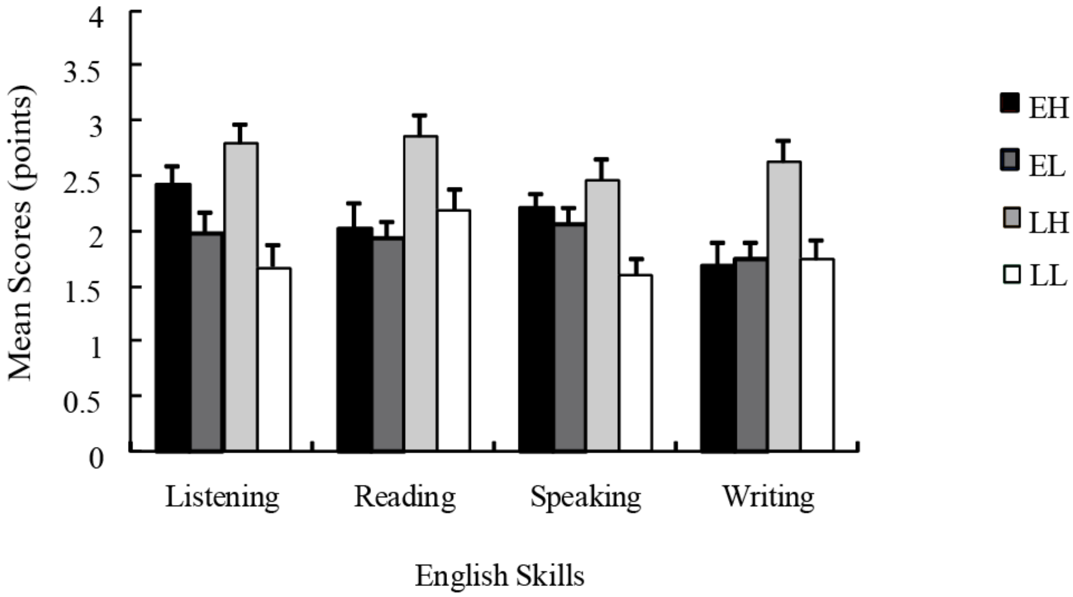


Figure 4.1. The self-rated English proficiency in listening, reading, speaking, and writing skills. Rating scale used: 0 = *scarcely*, 1 = *not sufficiently*, 2 = *sufficiently*, 3 = *well*, and 4 = *perfectly*. The error bars represent standard errors in the figure.

Table 4.7

Descriptive Statistics for the Self-Rated English Proficiency

		Listening	Reading	Speaking	Writing
Group	*n*	*M* (*SD*)	*M* (*SD*)	*M* (*SD*)	*M* (*SD*)
EH	23	2.42 (0.75)	2.02 (0.85)	2.21 (0.82)	1.68 (0.94)
EL	20	1.98 (1.02)	1.93 (0.71)	2.05 (0.81)	1.75 (0.85)
LH	23	2.80 (0.67)	2.86 (0.74)	2.45 (0.92)	2.63 (0.73)
LL	21	1.67 (0.97)	2.19 (0.66)	1.60 (0.90)	1.74 (0.83)

4.5.2 Materials

The materials consisted of English stimuli for the following three conditions: *Case*, *Present* (subject-verb agreement), and *Past* (past tense inflection). All stimulus sentences are shown in Appendix B.

Examples of the stimulus sentences are given in (12) for the Case condition, (13) for the Present condition, and (14) for the Past condition in each section below. Each condition was divided into two subtypes, each of which had 30 grammatical and 30 ungrammatical sentences. Therefore each condition had 60 grammatical and 60 ungrammatical sentences in total. Each simple sentence or embedded sentence was six to nine words in length with ADVP in front of the sentence if any. All words were found in English textbooks widely used in Japanese junior high schools, the *New Horizon English Course 1, 2, and 3* (Tokyo Syoseki).

4.5.2.1 Case Condition

One type of the Case condition was a simple sentence, of which the object was a PRN valued for accusative Case, as shown in (12a). The other type was an embedded sentence where the subject of the embedded clause was a PRN valued for nominative Case, as shown in (12b). The PRN *her*, which shares accusative and nominative Case, was not used.

(12) Case Condition

a. Every morning, the strange noise wakes *me*/**I* up.

b. I am sorry that *I*/**me* have no money with me today.

4.5.2.2 Present Condition

For the Present and Past conditions, Vs used were restricted to regular thematic Vs, and Ns used for the subject DPs were restricted to the 3rd-person plural-number regular Ns in order to test JLEs' sensitivities to subject-verb disagreement only in number in English.

Firstly, the reason for the restrictive use of 3rd-person Ns with the subject DPs was to avoid a repetition effect. That is, the participants could learn or expect what the coming V's inflection would be by the repetition of 1st and 2nd-person PRNs *I, We,* and *You*: In English PRNs, 1st-person is only *I* for the singular-number and *We* for the plural-number, and 2nd-person is only *You,* which is interpreted in both plural and singular-numbers. Concerning the other restrictions, the restrictive use of plural-number regular Ns as the subject DPs was connected to the neural mechanism of word processing: The processing of regular inflection was assumed to differ from that of irregular inflection (Rodriguez-Fornells, Clahsen, Lleo, Zaake, & Münte, 2001), and the nature of the sentence's grammaticality was often ambiguous as to whether the ungrammaticality of stimulus sentences could result from the absence of the subject-verb agreement marker (-*s*) or that of the past tense marker (-*ed*) if the proper marker on the sentence was missing (Osterhout & Mobley, 1995).

One type of the Present condition had a quantifier (e.g., *many*) or a numeral (e.g., *two*) in front of the subject DP for characterizing the plurality of the subject in a sentence as shown in (13a), and the other type did not have either of them as shown in

(13b).

(13) Present Condition

a. Many boys *like*/**likes* movies with action.

b. Every evening, the little sisters *help*/**helps* their mother.

4.5.2.3 Past Condition

The Past condition was based on the Present condition. By positioning a past tense ADVP in front of a main clause of the Present condition, the V in the sentence was supposed to be inflected for the past tense form as shown in (14a) that was based on (13a), and in (14b) that was based on (13b).

(14) Past Condition

a. In those days, many boys *liked*/**like* movies with action.

b. Last night, the little sisters *helped*/**help* their mother.

4.5.3 Procedure

Before the experiment, the participants completed a consent form, the assessment of handedness, and a questionnaire ("Questions about Language and the Experiment" for the JLE groups shown in Appendix A, and "Questions about Your Language and Travel Experience" for the ENS group shown in Appendix C), and they had the ERP recording procedures explained to them. The participants received specific instructions about the task, and were asked to read the sentences presented on a computer screen without blinking or moving while the sentences were being presented. After a detailed explanation of the experiment, the participants were seated on a comfortable chair in a soundproof and electrically shielded room, and faced a 17 in. Cathode Ray Tube monitor placed in front of them at a distance of 1 m.

In the experiment, a sentence was visually presented word by word in black letters in the center of a light gray computer screen. Figure 4.2 illustrates the experimental design of the task adopted in the experiment. Firstly, fixation points "::::" appeared in blue. The participants then pressed a button labeled *1* or *4* on a response pad placed on their lap for starting a sentence. Following a 500 ms delay, the first word of the sentence appeared. Each word was presented for 700 ms with a pause of 300 ms. After the presentation of the sentence, five question marks "?????" appeared in red. While the question marks were presented, the participants provided acceptability judgments for the presented sentence as quickly and accurately as possible. For the judgment, the participant pressed a button labeled *1* on the response pad if the participant thought the sentence was acceptable as English or pressed *4* if the participant thought the sentence was not acceptable as English. The next trial began 300 ms after the judgment. The participants had a practice session with 10 trials of each condition of stimuli that was followed by the experimental session. The stimuli were randomly presented and never repeated. There were six sessions with 60 trials each, and the presentation order of the six sessions was counterbalanced across the participants. To avoid boredom or fatigue, the participants took a short break between sessions in the experiment. EEG lasted approximately 2 hours, including a short break between sessions.

After the experiment, the JLE groups rated how well they understood the words in the experiment on "Questions about Language and the Experiment" shown in Appendix A, and took the *Oxford Placement Test* (UCLES, 2001).

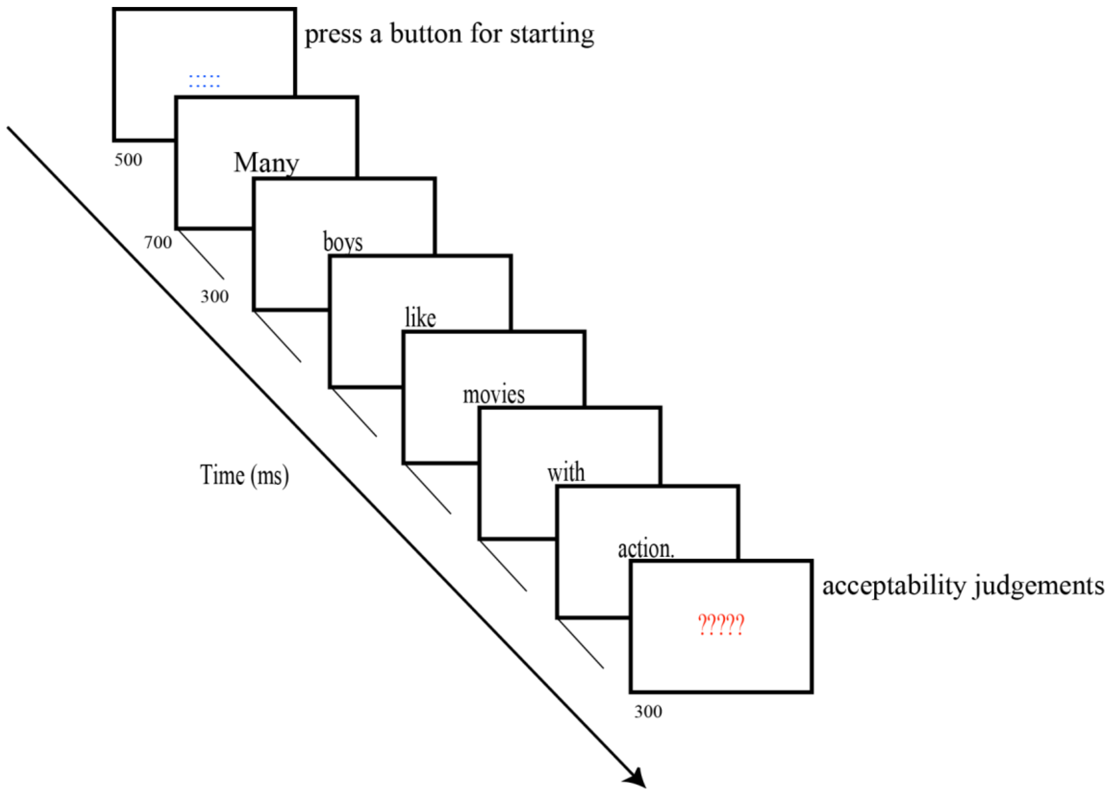


Figure 4.2. The experimental design of the task. In the experiment, the participants pressed a button for starting a sentence while fixation points “:::::” were presented in in blue in the center of a light gray computer screen. Following a 500 ms delay, a sentence was presented word by word in black letter for 700 ms with a pause of 300 ms. After the presentation of the sentence, the participants provided acceptability judgments for the presented sentence while question marks “?????” were presented in red. The next trial began 300 ms after the judgment.

4.5.4 ERP Recording

Electroencephalograms were continuously recorded using 123 Ag/AgCl sintered electrodes mounted on the Quick-Cap 128 (Compumedics USA, Charlotte, NC, USA). Additional electrodes were placed at the outer canthus of each eye and at the inferior orbital ridge for monitoring blinks and horizontal eye movements (VEOG: left canthus minus inferior orbital ridge; HEOG: left minus right canthus). All electrodes were referred to the linked left mastoid on-line and re-referenced to the linked right mastoids off-line. Figure 4.3 illustrates a scalp map of 123 channels, in which the electrode No. 64 was positioned at Cz. The electroencephalogram was amplified within a bandpass of 0.05–100 Hz and digitized on-line at 500 Hz. Impedances of all of the electrodes were set below 5 kΩ throughout the experiment.

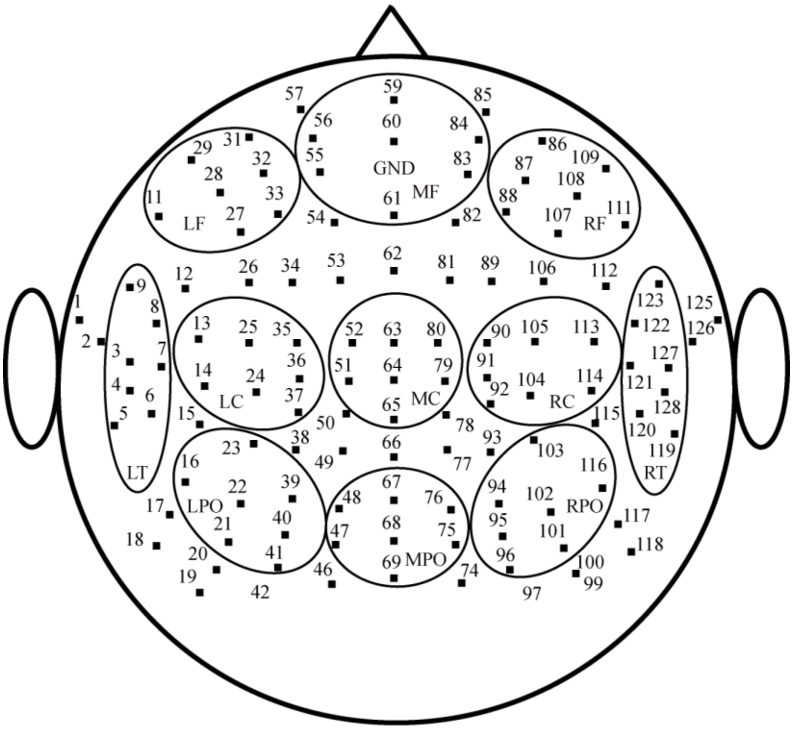


Figure 4.3. Scalp map of 123 channels. The circled clusters were used for statistical analyses. LT = left temporal; LF = left frontal; LC = left central; LPO = left parietal occipital; RF = right frontal; RC = right central; RPO = right parietal occipital; RT = right temporal; MF = middle frontal; MC = midline central; MPO = midline parietal occipital.

4.5.5 Data Analysis

In addition to the ERP results, behavioral results were reported. Reaction time and judgment accuracy were recorded during the experiment. Judgment accuracy is a crucial criterion used to evaluate the participant's sensitivity to the sentences as well as ERP. Therefore it is reported with a 6 × 5 (Grammaticality/Condition [grammatical or ungrammatical Case, grammatical or ungrammatical Present, grammatical or ungrammatical Past] × Group [ENS, EH, EL, LH, LL]) repeated measures ANOVA on the percentage of accuracy. Reaction times, however, were not reported because the responses showed the temporary delay between stimulus offset and the response signal, resulting in difficulties in interpretation (Mueller, 2009; Mueller, Hirotani, & Friederici, 2007).

ERPs were averaged for epochs of 1200 ms, which include 200 ms prior to the onset of the critical words in the sentences (baseline) and 1000 ms after the onset. Baseline corrections based, on the mean amplitude between –200 to the onset of the stimulus and off-line filtering with a high cut-pass frequency of 40 Hz, were applied. Epochs with excessive eye movement and other artifacts were excluded from the analysis of ERP responses through an artifact rejection process that was based on the peak-to-peak amplitude from –75 to +75 μV. The remaining ERPs of the three conditions (Case, Present, Past) were averaged for each participant. The ERP difference-waves were computed by subtracting a control ERP from its violation condition. The measures of difference wave characteristics were analyzed with each 100 ms time window at three midline regions of interest (ROI) (seven electrodes each for the frontal, central, and parietal occipital), and eight lateralized ROI (seven electrode each for the frontal, central, and parietal occipital in both the left and right hemispheres). The circled clusters in Figure 4.3 were used for the statistical analyses. Repeated measures ANOVAs utilizing the raw amplitude data of correct acceptability judgments together with the two subtypes, and a familywize alpha of .05, were performed for Condition (Case, Present, Past) with Grammaticality (grammatical, ungrammatical), Hemisphere (left, right), and ROI (frontal, temporal, central, parietal occipital) for the ENS group, and Age (Early, Late) and Proficiency (High, Low) for the JLE groups on the lateral sites, and with Grammaticality (grammatical, ungrammatical) and ROI (frontal, central, parietal occipital) for the ENS group, and Age (Early, Late) and Proficiency (High, Low) for the JLE groups on the midline site.

In addition, the peak latencies and amplitudes of the difference waves were calculated using ANOVAs to further determine the group effect on the components if necessary.

To reveal the effect in question, significant interactions in ANOVAs were tested using post-hoc Bonferroni multiple comparisons with alpha levels of .05.

Chapter 5 reports the behavioral (acceptability judgments) and ERP results.

Chapter 5

Results

Chapter 5 reports the behavioral results in section 5.1 and the ERP results in section 5.2.

5.1 Behavior Results

After the experiment, the JLE groups rated how well they understood the words in the experiment on "Questions about Language and the Experiment" shown in Appendix A: All of them reported that they understood all of the words perfectly.

The mean judgment accuracy of the Grammaticality/Condition (grammatical or ungrammatical Case, grammatical or ungrammatical Present, grammatical or ungrammatical Past) in each Group (ENS, EH, EL, LH, LL) is represented in Figure 5.1 and Table 5.1. The results of ANOVA are shown in Table 5.2.

The main effects were significant for Grammaticality/Condition, $F(5, 495) = 29.42$, $MSE = 141.24$, $p < .001$, and Group, $F(4, 99) = 9.86$, $MSE = 348.51$, $p < .001$, , and the interaction of the Grammaticality/Condition × Group, $F(20, 495) = 4.62$, $MSE = 141.24$, $p < .001$. The simple effect tests for Grammaticality/Condition indicated that the ENS group, $F(5, 81) = 7.40$, $MSE = 23.71$, $p < .001$, and LH, $F(5, 110) = 7.64$, $MSE = 100.73$, $p < .001$, judged the ungrammatical Case significantly more accurately than the other Grammaticality/Condition except for the ungrammatical Present, and EL, $F(5, 95) = 11.71$, $MSE = 234.01$, $p < .001$, and LL, $F(5, 100) = 15.37$, $MSE = 206.26$, $p < .001$, judged the ungrammatical Present and the ungrammatical Past significantly less accurately than the other Grammaticality/Condition. The simple effect tests for Group indicated that the ENS and High groups judged the ungrammatical Present, $F(4, 99) = 8.18$, $MSE = 486.56$, $p < .001$, and the ungrammatical Past, $F(4, 99) = 8.54$, $MSE = 251.71$, $p < .001$, significantly more accurately than the Low groups.

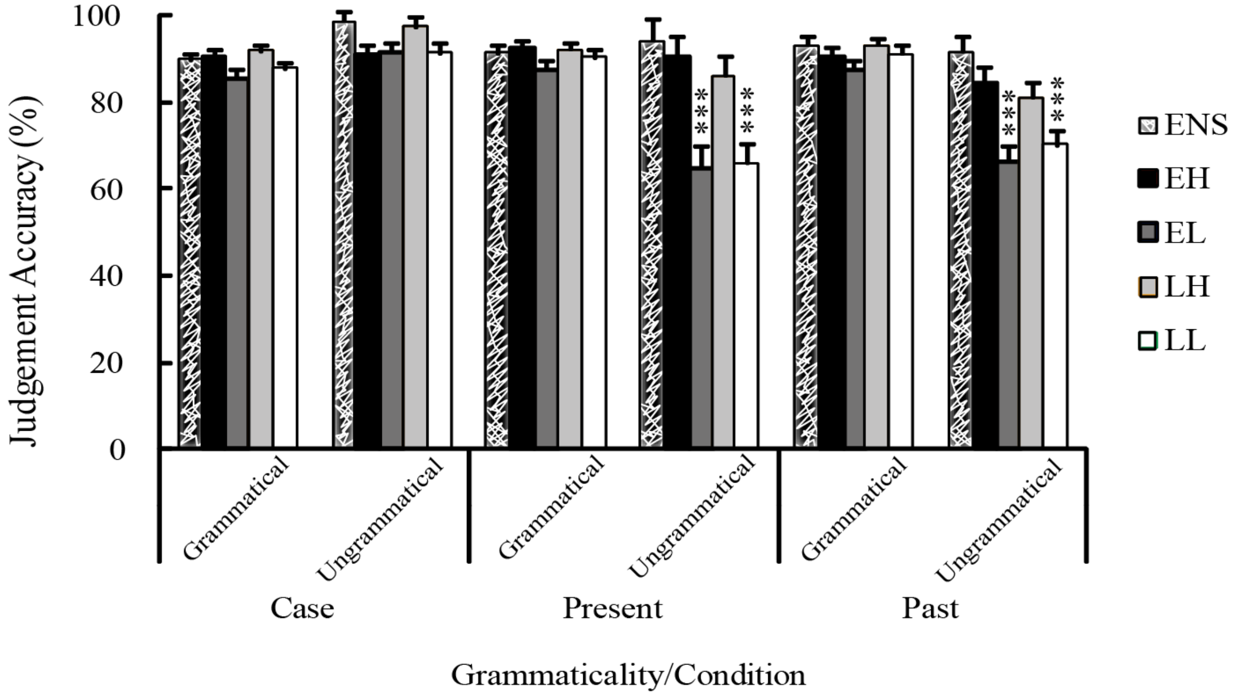


Figure 5.1. The mean judgment accuracy. ENS = the group of English native speakers; EH = Early-High; EL = Early-Low; LH = Late-High; LL = Late-Low. The error bars represent standard errors in the figure. The scores that differed from the ENS group within each Grammaticality/Condition are indicated (****p* < .001).

Table 5.1

Descriptive Statistics for a Percentage of the Judgment Accuracy

		Case		Present		Past	
		Grammatical	Ungrammatical	Grammatical	Ungrammatical	Grammatical	Ungrammatical
Group	*n*	*M* (*SD*)	*M* (*SD*)	*M* (*SD*)	*M* (*SD*)	*M* (*SD*)	*M* (*SD*)
ENS	17	89.44 (5.15)	98.33 (1.81)	90.92 (7.01)	93.70 (5.98)	92.87 (7.56)	91.20 (5.74)
EH	23	90.22 (5.01)	90.80 (20.04)	92.25 (7.87)	90.29 (16.47)	90.51 (8.14)	84.56 (12.03)
EL	20	85.50 (12.33)	91.17 (7.16)	87.50 (13.67)	64.92 (30.86)	87.50 (13.63)	66.17 (18.84)
LH	23	91.52 (4.66)	97.17 (2.21)	91.67 (6.18)	85.65 (16.63)	92.68 (5.74)	80.80 (17.44)
LL	LL	87.54 (6.89)	91.16 (7.20)	89.93 (8.14)	65.51 (29.29)	90.87 (6.70)	69.93 (19.65)

Table 5.2

Analysis of Variance for the Judgment Accuracy

Source	*df*	*F*	*p*
		Between subject	
Group	4	9.86***	.000
Errors	99		
		Within subject	
Skill	5	29.42***	.000
Skill × Group	20	4.62***	.000
Errors	495		

****p* < .001.

5.2 ERP Results

To assess the relatively early negative ERP components, ELAN and LAN, the time windows from 100 to 200 ms and from 300 to 500 ms were selected, respectively, on the basis of the neurophysiological model of language processing, which was proposed by Friederici (2002). However, a late positive ERP component, P600, could have occasionally delayed the peak latencies in L2 learners (e.g., Hahne, 2001; Rossi, et al., 2006; Weber-Fox & Neville, 1996), thus, the long time window from 500 to 800 ms was selected to assess the appearance of P600.

5.2.1 Case Condition

Grand averaged ERPs for the Case condition in the ENG group, EH, EL, LH, and LL are shown in Figures 5.2, 5.3, 5.4, 5.5, and 5.6. The scalp topographies for the Case condition in each group are plotted in Figure 5.7. The results of the mean amplitude ANOVAs for the Case condition in the ENG and JLE groups are summarized in Tables 5.3 and 5.4, respectively.

At first glance in the ERPs and the scalp topographies for the Case condition, the ungrammatical Case seems to have elicited a biphasic ERP pattern with an anterior negativity followed by a later positivity in the ENS group. This pattern also seems to have been elicited in the JLE groups with different voltage degrees and distributions depending on the JLE groups.

5.2.1.1 Case Condition in the ENS Group

In the time window from 100 to 200 ms for ELAN, the interaction of Grammaticality × ROI was significant at the lateral sites, $F(3, 48) = 4.26$, $MSE = 0.19$, $p = .042$, and at the midline site, $F(2, 32) = 4.22$, $MSE = 0.26$, $p = .024$, without the significant main effect of Grammaticality in each ROI at either the lateral or midline sites (100–200 ms). The result suggested that ELAN was not elicited.

In the time window from 300 to 500 ms for LAN, only the main effect of Grammaticality was significant at the lateral sites (300–400 ms), $F(1, 16) = 13.00$, $MSE = 0.41$, $p = .002$, and at the midline site (300–400 ms), $F(1, 16) = 14.50$, $MSE = 0.28$, $p = .002$. Thus, this negativity was not LAN, but negativity with a broad distribution from 300 to 400 ms after the stimulus.

In the time window from 500 to 800 ms for P600, the main effect of Grammaticality, $F(1, 16) = 26.08$, $MSE = 0.39$, $p < .001$, and the interaction of Grammaticality × ROI, $F(3, 48) = 3.79$, $MSE = 0.05$, $p = .006$, were significant at the lateral sites (500–600 ms). The main effect of Grammaticality was also significant at the midline site (500–600 ms), $F(1, 16) = 21.96$, $MSE = 0.30$, $p < .001$. The main effect of Grammaticality and the interaction of Grammaticality × ROI were continuously significant at the lateral sites, (600–700 ms): $F(1, 16) = 29.99$, $MSE = 0.53$, $p < .001$, and $F(3,48) = 8.14$, $MSE = 0.05$, $p < .001$, respectively, and (700–800 ms): $F(1, 16) = 10.92$, $MSE = 0.55$, $p = .004$, and $F(3, 48) = 8.52$, $MSE = 0.10$, $p < .001$, respectively, and also at the midline site, (600–700 ms): $F(1, 16) = 33.48$, $MSE = 0.26$, $p < .001$, and $F(2, 32) = 9.54$, $MSE = 0.54$, $p = .001$, respectively, and (700–800 ms): $F(1, 16) = 8.05$, *MSE* = 0.33, p = .012, and $F(2, 32) = 11.84$, *MSE* = 0.09, $p < .001$, respectively. The simple effect tests for ROI at the lateral sites indicated positivity at all ROIs (frontal, temporal, central, parietal occipital) (500–600 ms) and more restricted to three more parietal ROIs (temporal, central, parietal occipital) (600–800 ms). Similarly, the simple effect tests for ROI at the midline site indicated that positivity also appeared at all ROIs (MF, MC, MPO) (600–700 ms), and more restricted to two more parietal ROIs (MC, MPO) (700–800 ms). Accordingly, positivity was elicited, where onset was between 500 to 600 ms after the stimulus and distributed more parietal ROIs as the later time windows: This positivity could be P600.

These statistic findings indicated that the ungrammatical Case elicited an early negativity with a broad distribution, which was followed by P600, in the ENS group.

5.2.1.2 Case Condition in the JLE Groups

In the time window from 100 to 200 ms for ELAN, neither the main effect of Grammaticality nor the interaction by Grammaticality was significant at the lateral or midline sites, which suggested that ELAN was elicited in none of the JLE groups.

In the time window from 300 to 500 ms for LAN, the main effect of Grammaticality was significant at the lateral sites (300–400 ms), $F(1, 83) = 6.37$, *MSE* = 0.99, p = .014, and the interaction of Grammaticality × ROI × Age × Proficiency was significant at the midline site (400–500 ms), $F(2, 166) = 3.72$, *MSE* = 0.06, p = .026. The post-hoc tests showed that the interaction of Grammaticality × ROI × Age × Proficiency at the midline site (400–500 ms) was due to the lack of the main effect of Grammaticality in the Early groups. The statistical analyses confirmed that an early negativity with a broad distribution was elicited from 300 to 400 ms after the stimulus in the Early groups, and from 300 to 500 in the Late groups.

In the time window from 500 to 800 ms for P600, the main effect of Grammaticality and the interaction of Grammaticality × ROI were continuously significant at the lateral sites, (500–600 ms): $F(1, 83) = 8.22$, *MSE* = 1.17, p = .005, and

$F(3,249) = 4.07$, $MSE = 0.08$, $p = .008$, respectively, and (600–700 ms): $F(1, 83) = 9.53$, $MSE = 1.57$, $p = .003$, and $F(3, 249) = 4.45$, $MSE = 0.12$, $p = .005$, respectively, and at the midline site, (500–600 ms): $F(1, 83) = 13.54$, $MSE = 0.50$, $p < .001$, and $F(2, 166) = 5.24$, $MSE = 0.11$, $p = .006$, respectively, and (600–700 ms): $F(1, 83) = 8.92$, $MSE = 0.73$, $p = .004$, and $F(2, 166) = 10.46$, $MSE = 0.11$, $p < .001$, respectively. The simple effect tests for ROI (500–600 ms) indicated that the interaction reflected positivity at the central region in LH at the lateral sites, at MPO in EL, at MC in LH, and at MC in LL at the midline site. Similarly, the simple effect tests for ROI (600–700 ms) indicated that the interaction reflected positivity at the parietal occipital region in EH, at the central region in LH, and at the central and parietal occipital regions in LL at the lateral sites, and at MPO in EH, at MC in LH, and at MC and MPO in LL at the midline site. The interaction of Grammaticality × ROI was also significant at the lateral sites (700–800 ms), $F(3, 249) = 5.54$, $MSE = 0.12$, $p = .001$, and at the midline site (700–800 ms), $F(2, 166) = 13.41$, $MSE = 0.10$, $p < .001$, without any significant main effect of Grammaticality. To summarize, a late positivity was elicited from 500 to 700 ms after the stimulus at the central region in LH and at the central and parietal occipital regions in LL, from 500 to 600 ms at the central and parietal occipital regions only at the midline site in EL, and from 600 to 700 ms at the parietal occipital region in EH: These positivities could be P600.

These statistic findings indicated that the ungrammatical Case elicited an early negativity with a broad distribution, which was followed by P600 with different time windows according to the JLE groups.

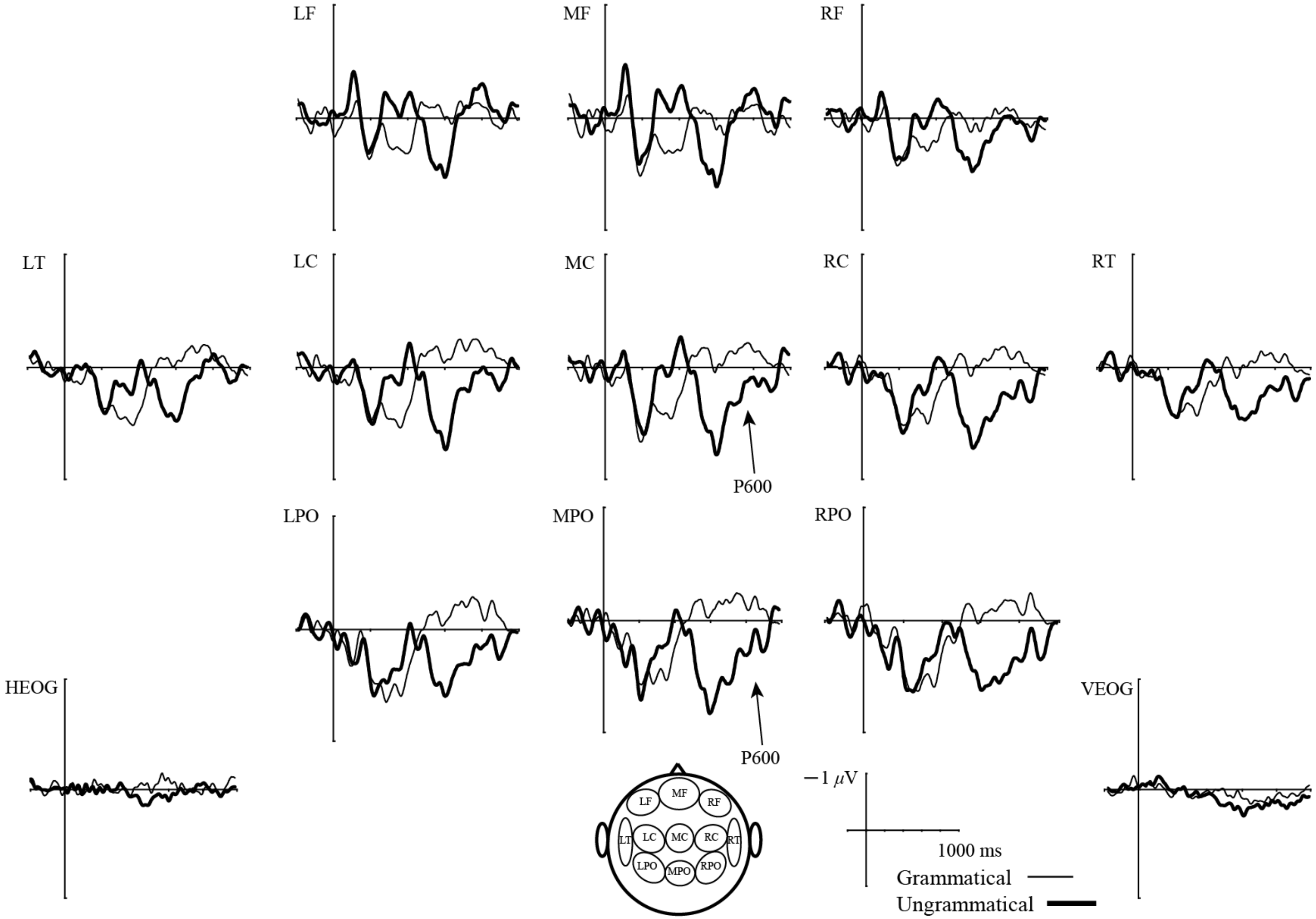


Figure 5.2. Grand averaged ERPs for the Case condition in the ENS group, which were averaged across seven electrodes in each ROI. LT = left temporal; LF = left frontal; LC = left central; LPO = left parietal occipital; RF = right frontal; RC = right central; RPO = right parietal occipital; RT = right temporal; MF = middle frontal; MC = midline central; MPO = midline parietal occipital.

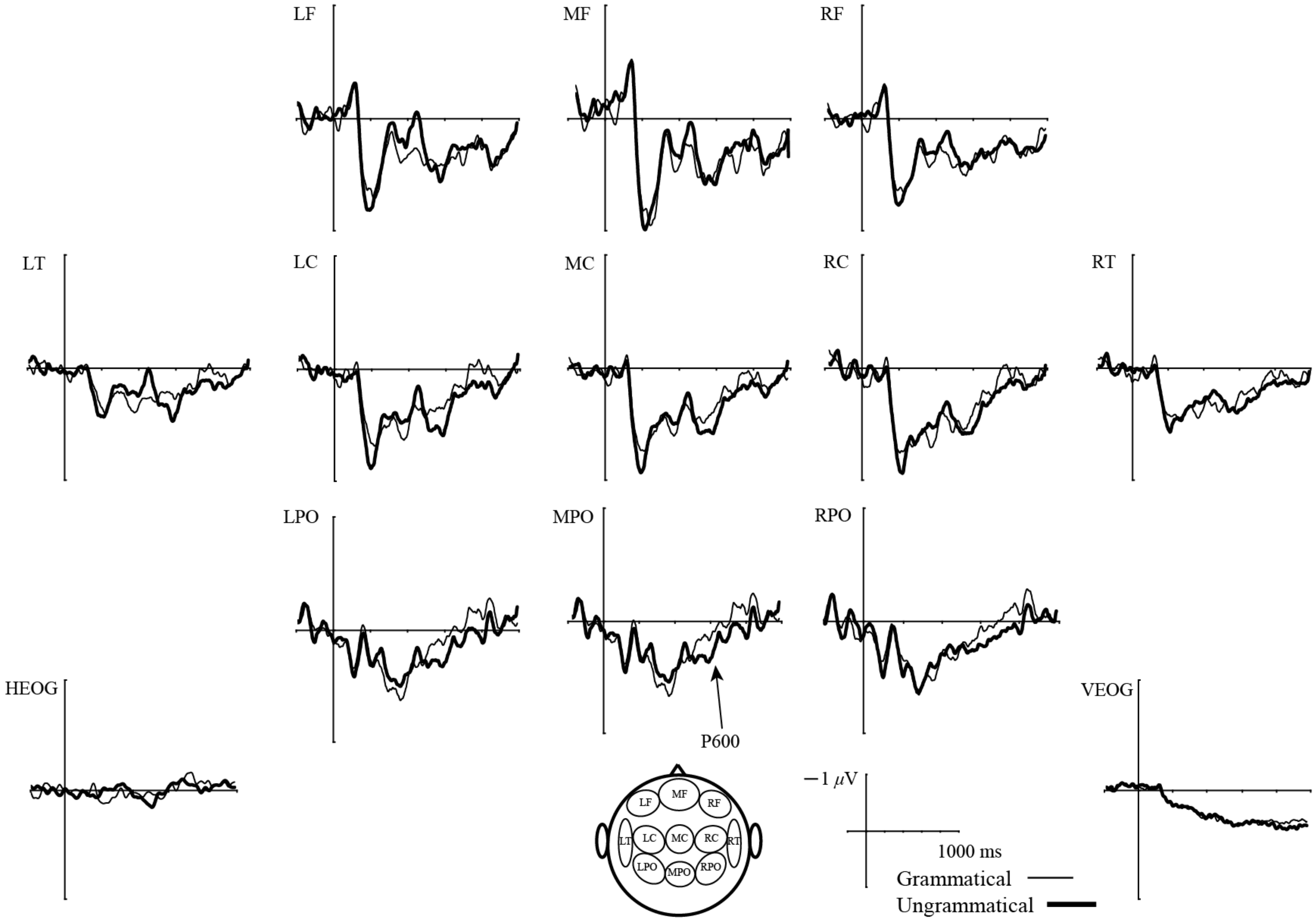


Figure 5.3. Grand averaged ERPs for the Case condition in EH, which were averaged across seven electrodes in each ROI.

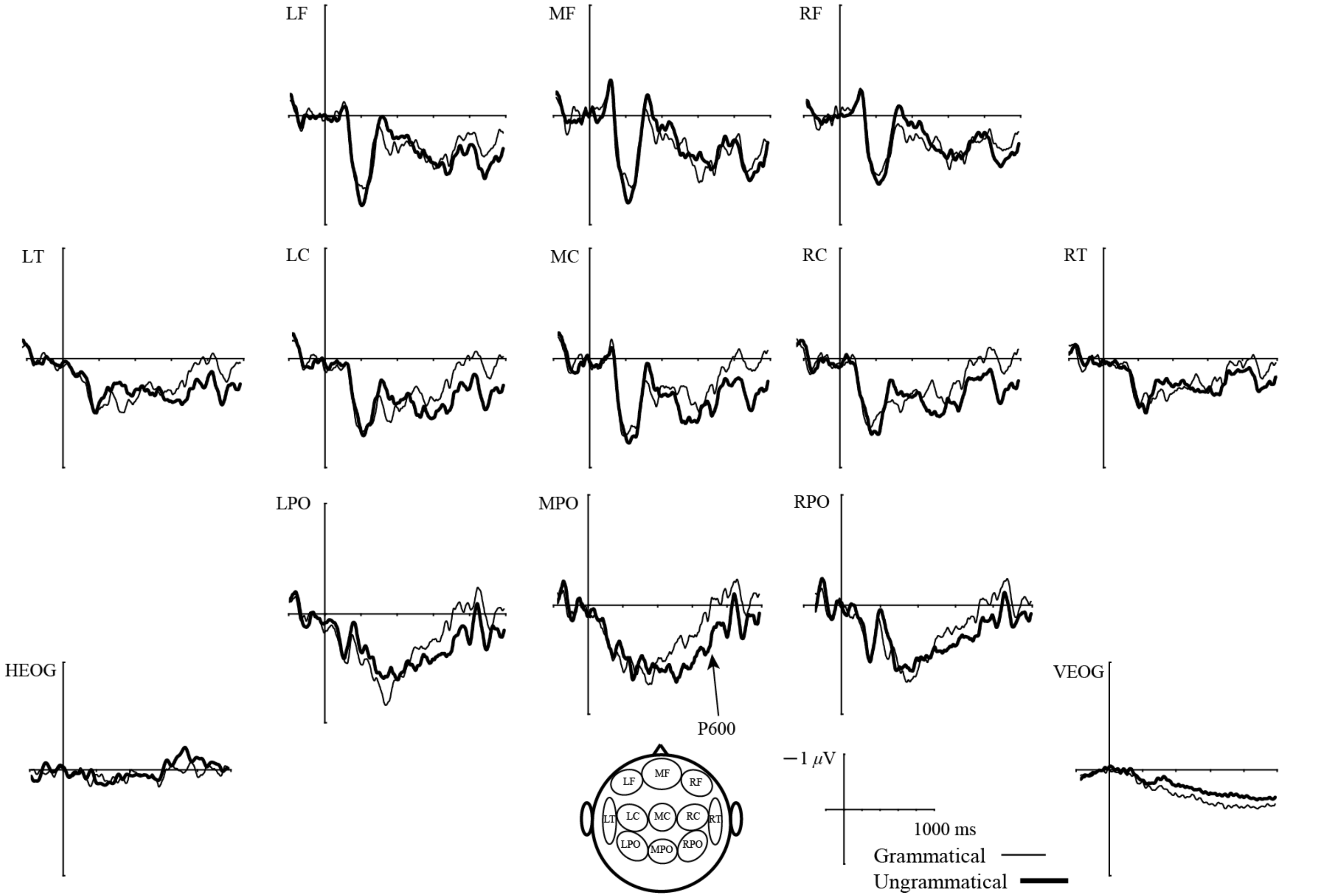


Figure 5.4. Grand averaged ERPs for the Case condition in EL, which were averaged across seven electrodes in each ROI.

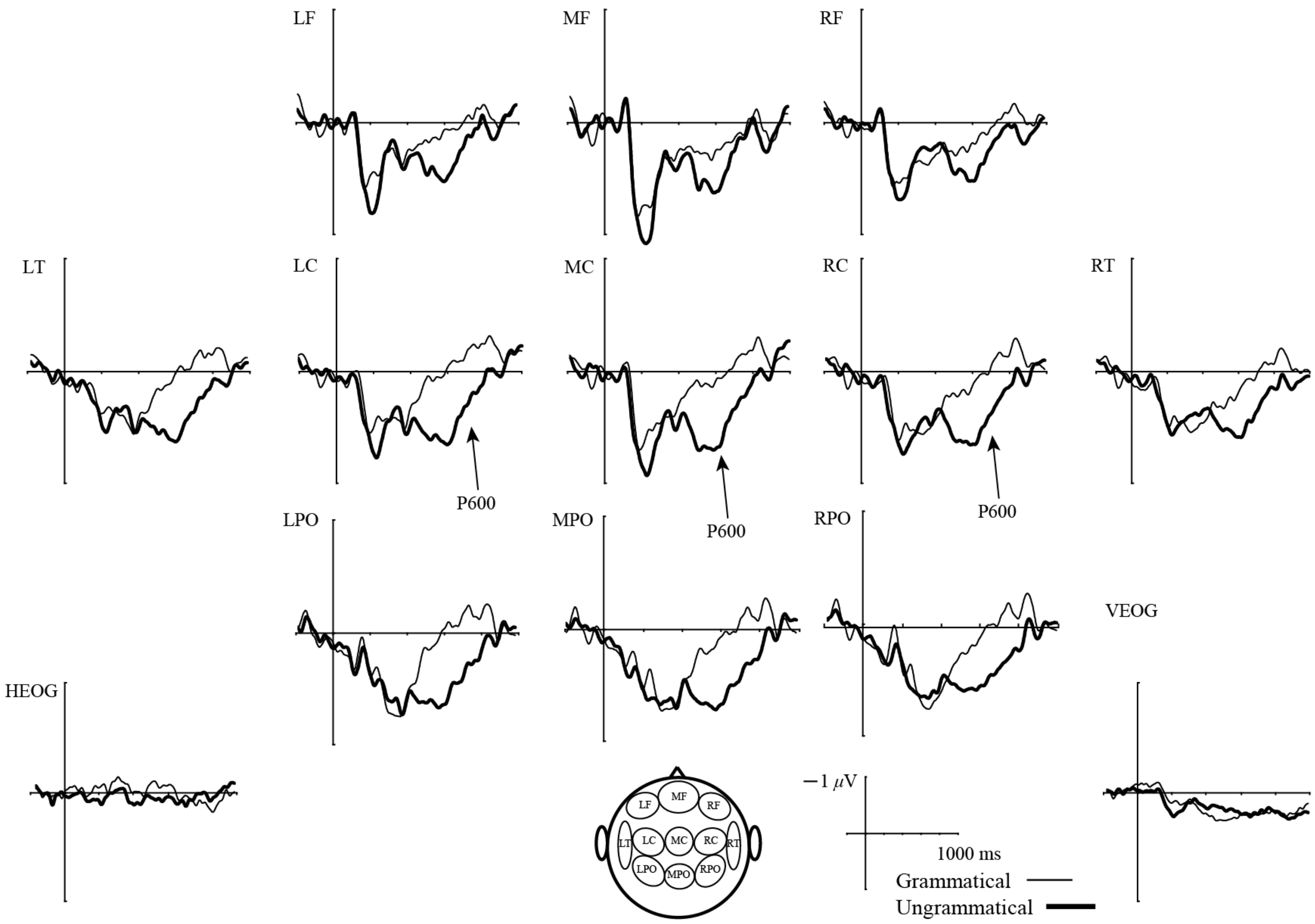


Figure 5.5. Grand averaged ERPs for the Case condition in LH, which were averaged across seven electrodes in each ROI.

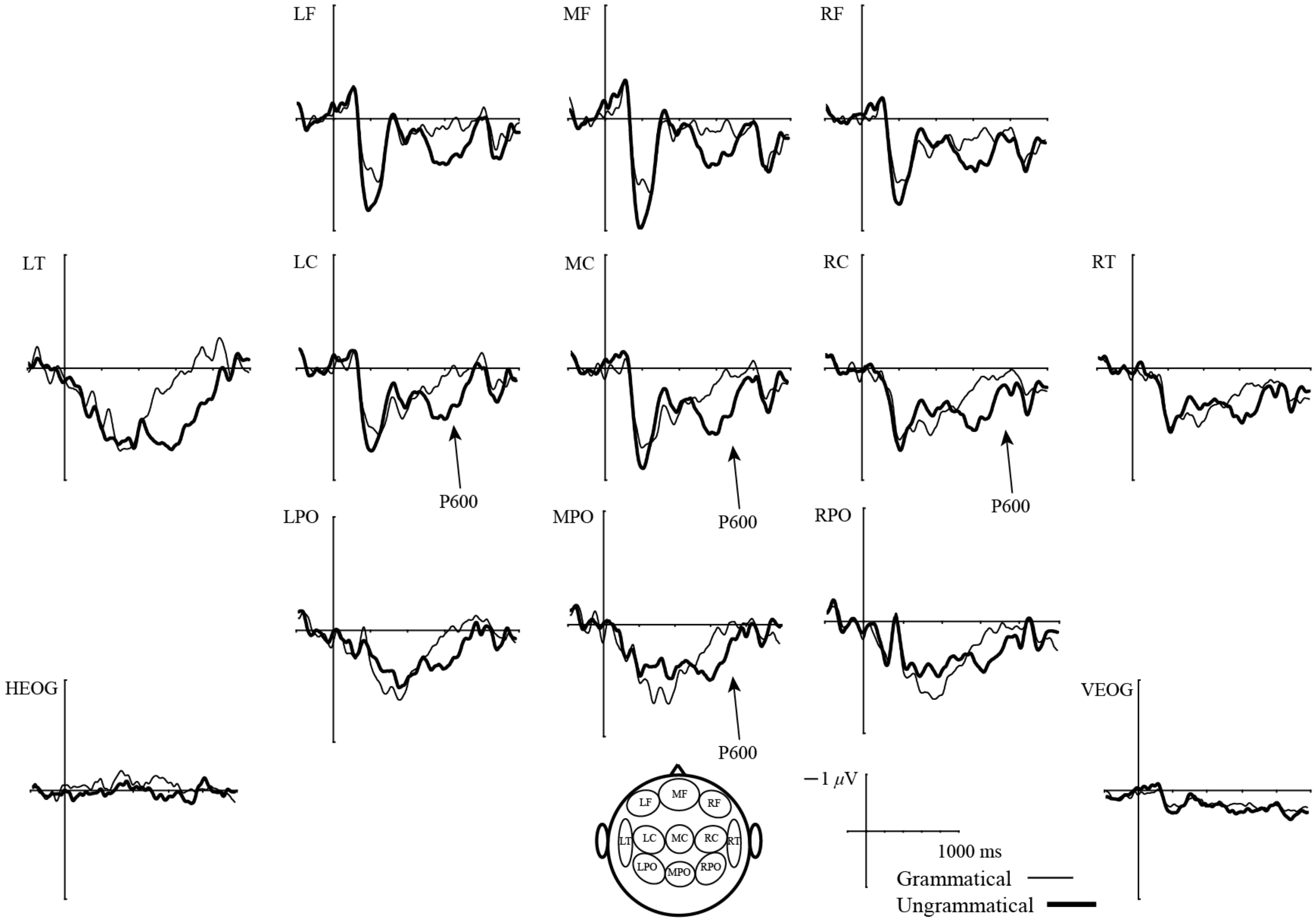


Figure 5.6. Grand averaged ERPs for the Case condition in LL, which were averaged across seven electrodes in each ROI.

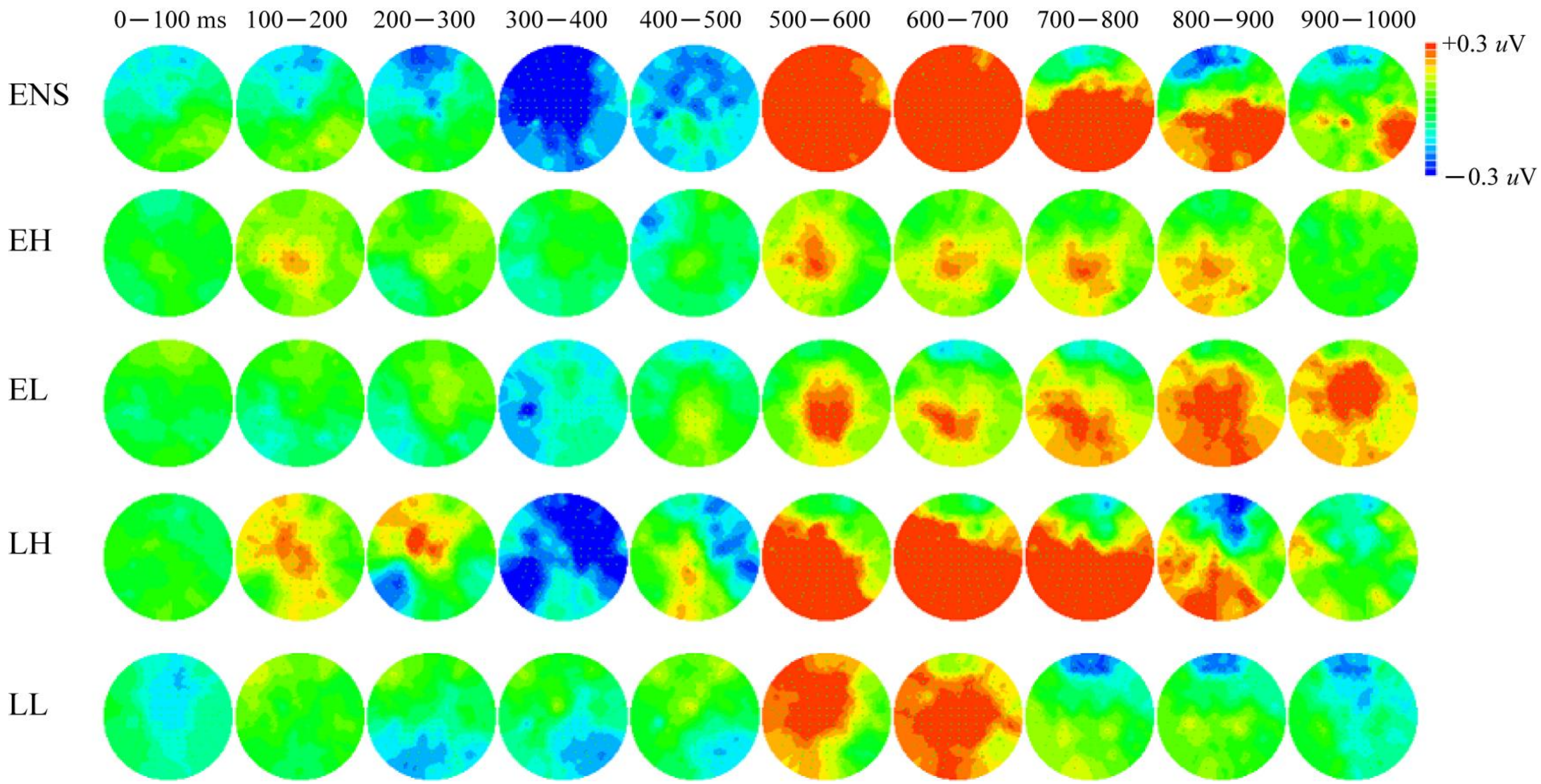


Figure 5.7. Scalp topographies for the Case condition in each group. Differences in potential values were computed by subtracting a control ERP from its violation condition (ungrammatical Case – grammatical Case).

Table 5.3

Summary of the Mean Amplitude Analysis of Variance for the Case Condition in the ENS Group

		Latency (ms)									
Factor	*df*	0–100	100–200	200–300	300–400	400–500	500–600	600–700	700–800	800–900	900–100
Lateral											
G	1, 16				13.00**		26.08***	29.99***	10.92**		
G × H	1, 16									4.69*	
G × R	3, 48	4.13*	4.26*				3.79*	8.14**	8.52**	6.14*	
G × H × R	3, 48										
Midline											
G	1, 16			4.77*	14.50**		21.96***	33.48***	8.05*		
G × R	2, 32	3.92*	4.22*	5.23*				9.54**	11.84**	8.18**	

Note. G = Grammaticality (grammatical, ungrammatical); H = Hemisphere (left, right); R = ROI.
$*p < .05$; $**p < .01$; $***p < .001$.

Table 5.4

Summary of the Mean Amplitude Analysis of Variance for the Case Condition in the JLE Groups

		Latency (ms)									
Factors	*df*	0–100	100–200	200–00	300–400	400–500	500–600	600–700	700–800	800–900	900–100
Lateral											
G	1, 83				6.37*		8.22**	9.53**			
G × A	1, 83										
G × P	1, 83										
G × A × P	1, 83										
G × H	1, 83										
G × H × A	1, 83										
G × H × P	1, 83										
G × H × A × P	1, 83										
G × R	3, 249			3.33*			4.07*	4.45**	5.54**		
G × R × A	3, 249										
G × R × P	3, 249										
G × R × A × P	3, 249										
G × H × R	3, 249										
G × H × R × A	3, 249										
G × H × R × P	3, 249										
G × H × R × A × P	3, 249										
Midline											
G	1, 83						13.54***	8.92**			
G × A	1, 83										
G × P	1, 83										
G × A × P	1, 83										
G × R	2, 166						5.24*	10.46***	13.41***	8.85**	
G × R × A	2, 166										
G × R × P	2, 166										
G × R × A × P	2, 166					3.72*					

Note. G = Grammaticality (grammatical, ungrammatical); H = Hemisphere (left, right); R = ROI; A = Age (Early, Late); P = Proficiency (High, Low).
*p < .05; **p < .01; ***p < .001.

5.2.1.3 Group Effect in the Case Condition

To assess a group effect on the processing of the Case condition, the peak latencies and amplitudes of the early negativity at the lateral sites (300–400 ms) (Figure 5.8), where a significant negative deflection was observed, and P600 at the midline site[1] (500–800 ms) (Figure 5.9) were calculated in all of the groups. For both the early negativity and P600, the peak latencies were not significantly different among the groups, whereas the peak amplitudes in the JLE groups were significantly reduced relative to the ENS group for the early negativity, $F(4, 99) = 4.61$, $MSE = 0.16$, $p = .014$, and for P600, $F(4, 99) = 3.45$, $MSE = 0.05$, $p = .034$.

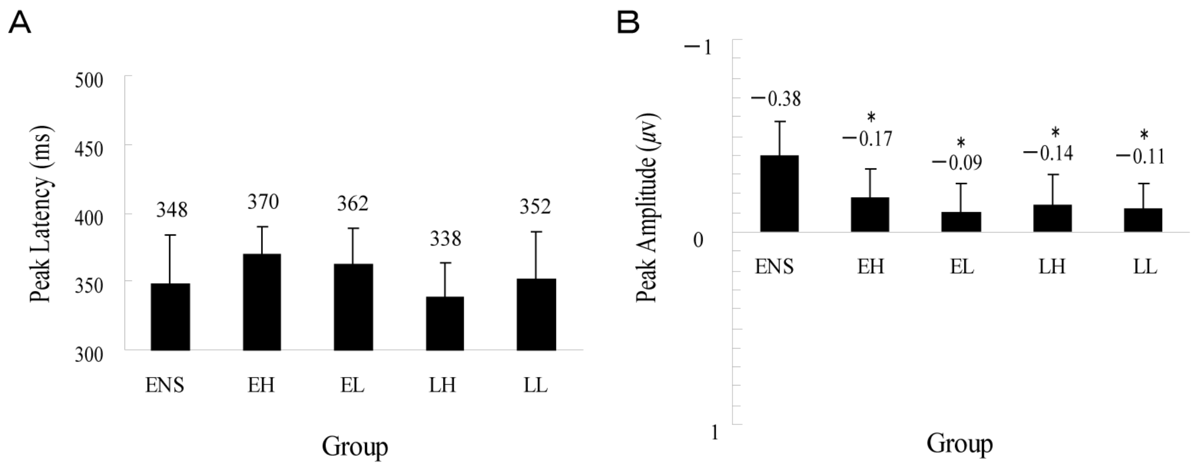


Figure 5.8. Group comparison of the early negativity at the lateral sites (300–400 ms) for the Case condition. The error bars indicate standard errors in the figure. The values that differed from the ENS group are indicated (*$p < .05$). (A) Mean peak latency (ms). (B) Mean peak amplitude (μV).

[1] P600 was elicited not across the midline site but in different ROIs depending on the groups. Due to the distribution difference, the group comparison of the peak latency and amplitude of P600 might be incomprehensible in principle.

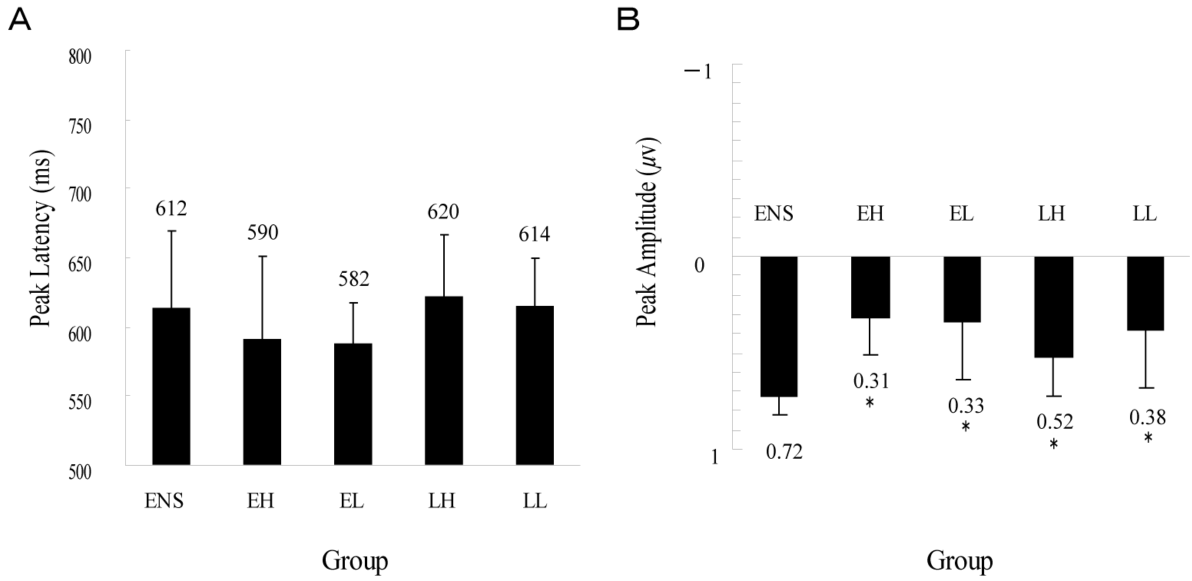


Figure 5.9. Group comparison of P600 at the midline site (500–800 ms) for the Case condition. The error bars represent standard errors in the figure. The values that differed from the ENS group are indicated (*p < .05). (A) Mean peak latency (ms). (B) Mean peak amplitude (μV).

5.2.2 Present Condition

Grand averaged ERPs for the Present condition in the ENG group, EH, EL, LH, and LL are shown in Figures 5.10, 5.11, 5.12, 5.13, and 5.14. The scalp topographies for the Present condition in each group are plotted in Figure 5.15. The results of the mean amplitude ANOVAs for the Present condition in the ENG and JLE groups are summarized in Tables 5.5 and 5.6, respectively.

In the figures, the ungrammatical Present seems to have elicited a biphasic ERP pattern with negativity, which is followed by a late positivity, in the ENS group and LH. On the other hand, the ungrammatical Present seems to have elicited only positivity starting at 400 ms after the stimulus in EH, and a weak anterior sustained negativity in EL. In LL, positivity and negativity seem to have co-occurred in the same time window for the ungrammatical Present.

5.2.2.1 Present Condition in the ENS Group

In the time window from 100 to 200 ms for ELAN and that from 300 to 500 ms for LAN, neither the main effect of Grammaticality nor the interaction by Grammaticality was significant at the lateral or midline sites, which suggested that neither ELAN nor LAN was elicited. Because a negative deflection was observed by visual inspection of ERPs and the scalp topographies, additional ANOVAs were performed for each 50 ms time window between 300 and 500 ms after the stimulus. The analyses at the lateral sites (400–450 ms) revealed the significant main effect of Grammaticality, $F(1,16) = 2.37$, $MSE = 0.91$, $p = .004$, and the significant interaction of Grammaticality × Hemisphere × ROI, $F(3, 48) = 5.03$, $MSE = 0.35$, $p = .003$, reflecting negativity at LF and LC. Similarly, ANOVAs at the midline site (400–450 ms) revealed the significant main effect of Grammaticality, $F(1, 16) = 2.34$, $MSE = 0.61$, $p = .003$, and the significant interaction of Grammaticality × ROI, $F(2, 32) = 6.14$, $MSE = 0.24$, $p = .001$, reflecting negativity at MF and MC. Accordingly, this early negativity would be LAN.

In the time window from 500 to 800 ms for P600, the main effect of Grammaticality was continuously significant at the lateral sites, (500–600 ms): $F(1, 16) = 4.96$, $MSE = 0.54$, $p = .041$, and (600–700 ms): $F(1, 16) = 15.31$, $MSE = 0.40$, $p = .001$, and at the midline site, (500–600 ms): $F(1, 16) = 7.90$, $MSE = 0.29$, $p = .013$, and (600–700 ms): $F(1, 16) = 15.57$, $MSE = 0.23$, $p = .001$. The interaction of Grammaticality × ROI was significant only at the lateral sites (700–800 ms), $F(3, 48) = 4.02$, $MSE = 0.24$, $p = .012$, reflecting positivity at the parietal occipital region. In summary, a late positivity was elicited from 500 to 700 ms after the stimulus with a broad distribution, and it was then restricted to the parietal occipital region at the lateral sites from 700 to 800 ms after the stimulus; This positivity was expected to be P600.

These statistic findings indicated that the ungrammatical Present elicited a biphasic ERP pattern with LAN followed by P600 in the ENS group.

5.2.2.2 Present Condition in the JLE Groups

In the time window from 100 to 200 ms for ELAN, neither the main effect of Grammaticality nor the interaction by Grammaticality was found at the lateral or midline sites, which suggested that ELAN was elicited in none of the JLE groups.

In the time window from 300 to 500 ms for LAN, the interaction of Grammaticality × Age × Proficiency was significant at the lateral sites (300–400 ms), $F(1, 83) = 5.79$, $MSE = 0.45$, $p = .018$, reflecting negativity in LH, $F(1, 22) = 4.46$, $MSE = 0.79$, $p = .046$. The onset of negativity appeared from 200 to 300 ms after the stimulus according to ANOVA. In the subsequent time windows, the interaction of Grammaticality × Age × Proficiency and the interaction of Grammaticality × Age were significant at the lateral sites (400–500 ms), $F(1, 83) = 8.15$, $MSE = 0.93$, $p = .005$, and $F(1, 83) = 5.02$, $MSE = 0.93$, $p = .028$, respectively, reflecting positivity in EH, $F(1, 22) = 9.67$, $MSE = 0.25$, $p = .005$. In the same time windows at the midline site, the interaction of Grammaticality × Age × Proficiency (400–500 ms), $F(1, 83) = 7.74$, $MSE = 0.35$, $p = .007$, and the interaction of Grammaticality × ROI × Age × Proficiency (400–500 ms), $F(2, 166) = 5.81$, $MSE = 0.05$, $p = .004$, were significant, and this was due to the High groups, $F(2, 88) = 3.35$, $MSE = 0.06$, $p = .04$. Further analysis confirmed positivity in EH, $F(1, 22) = 6.02$, $MSE = 0.21$, $p = .023$, and negativity at MF in LH, $F(1, 22) = 5.13$, $MSE = 0.34$, $p = .034$. In short, negativity was elicited only in LH at the lateral sites from 300 to 400 ms after the stimulus and then at MF from 400 to 500 ms. Positivity in EH must be further analyzed in the following time windows in order to specify the component because this positivity was sustained in the ERPs and the scalp topographies.

In the time window from 500 to 800 ms for P600, the interaction of Grammaticality × Age × Proficiency was continuously significant at the lateral sites (500–600 ms), $F(1, 83) = 6.17$, $MSE = 1.51$, $p = .015$, reflecting positivity in EH, $F(1, 22) = 14.76$, $MSE = 0.35$, $p = .001$. At the midline site, the interaction of Grammaticality

× ROI × Age × Proficiency, the interaction of Grammaticality × Age × Proficiency, and the interaction of Grammaticality × Proficiency were significant (500–600 ms), $F(2, 166) = 3.61$, $MSE = 0.05$, $p = .029$, $F(1, 83) = 4.78$, $MSE = 0.33$, $p = .032$, and $F(1, 83) = 5.43$, $MSE = 0.33$, $p = .002$, respectively. The post-hoc tests revealed that the interaction of Grammaticality × ROI × Age × Proficiency at the midline site (500–600 ms) reflected positivity in EH, $F(1, 22) = 14.93$, $MSE = 0.20$, $p = .001$, and was due to the lack of the main effect of Grammaticality in LH, which suggested that this positivity, that appeared from 400 to 500 ms after the stimulus at the lateral sites in EH, was still observed from 500 to 600 ms but was more broadly distributed, and that negativity that appeared from 200 to 300 ms after the stimulus in LH disappeared before approximately 500 ms after the stimulus. Subsequently, the significant interaction of Grammaticality × Age × Proficiency was still observed at the lateral sites (600–700 ms), $F(1, 83) = 5.64$, $MSE = 0.74$, $p = .02$, reflecting positivity in EH, $F(1, 22) = 21.17$, $MSE = 0.23$, $p < .001$. At the midline site (600–700 ms), the main effect of Grammaticality, $F(1, 83) = 5.62$, $MSE = 0.38$, $p = .02$, and the interaction of Grammaticality × Proficiency, $F(1, 83) = 5.57$, $MSE = 0.38$, $p = .021$, were significant, which were due to positivity in the High groups, $F(1, 45) = 11.18$, $MSE = 0.41$, $p = .002$. Lastly, the interaction of Grammaticality × ROI was significant at the midline site (700–800 ms), $F(2, 166) = 4.66$, $MSE = 0.06$, $p = .011$, reflecting positivity at MC and MPO in EH. In summary, a late positivity was elicited with a broad distribution from 400 to 700 ms after the stimulus in EH, and a late positivity was elicited at the midline site from 600 to 700 ms after the stimulus in LH. Because the late positivity in EH was shown to have a centro-parietal distribution, it could be P600. Positivity at the midline site in LH might be P600, although the distribution was not typical of P600.

These statistical findings suggested that the ungrammatical Present elicited only P600 in EH and negativity with a broad distribution from 300 to 500 ms after the stimulus, which was followed by P600 in LH. Contrary to the High groups, no ERP component was elicited in the Low groups.

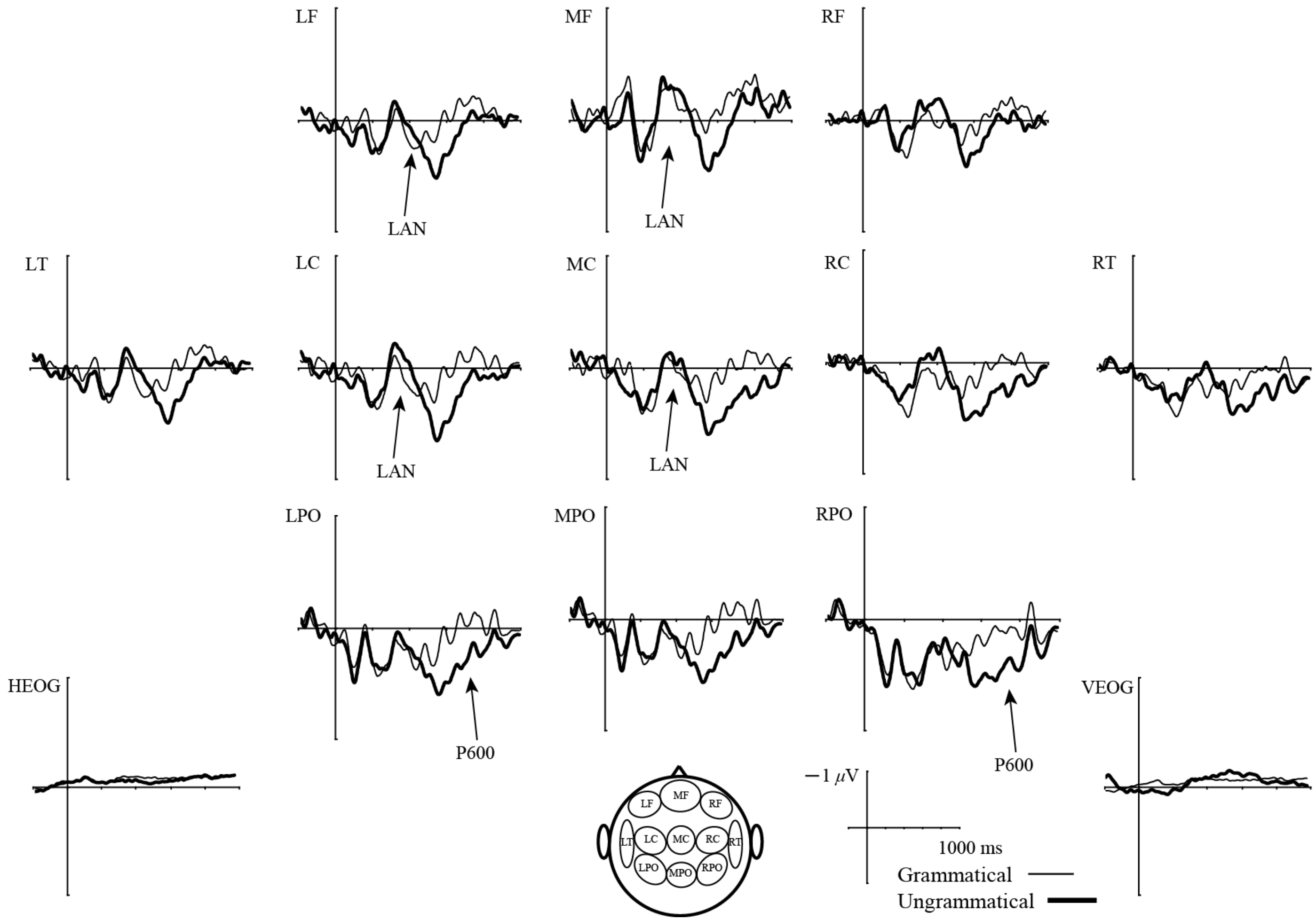


Figure 5.10. Grand averaged ERPs for the Present condition in the ENS group, which were averaged across seven electrodes in each ROI. LT = left temporal; LF = left frontal; LC = left central; LPO = left parietal occipital; RF = right frontal; RC = right central; RPO = right parietal occipital; RT = right temporal; MF = middle frontal; MC = midline central; MPO = midline parietal occipital.

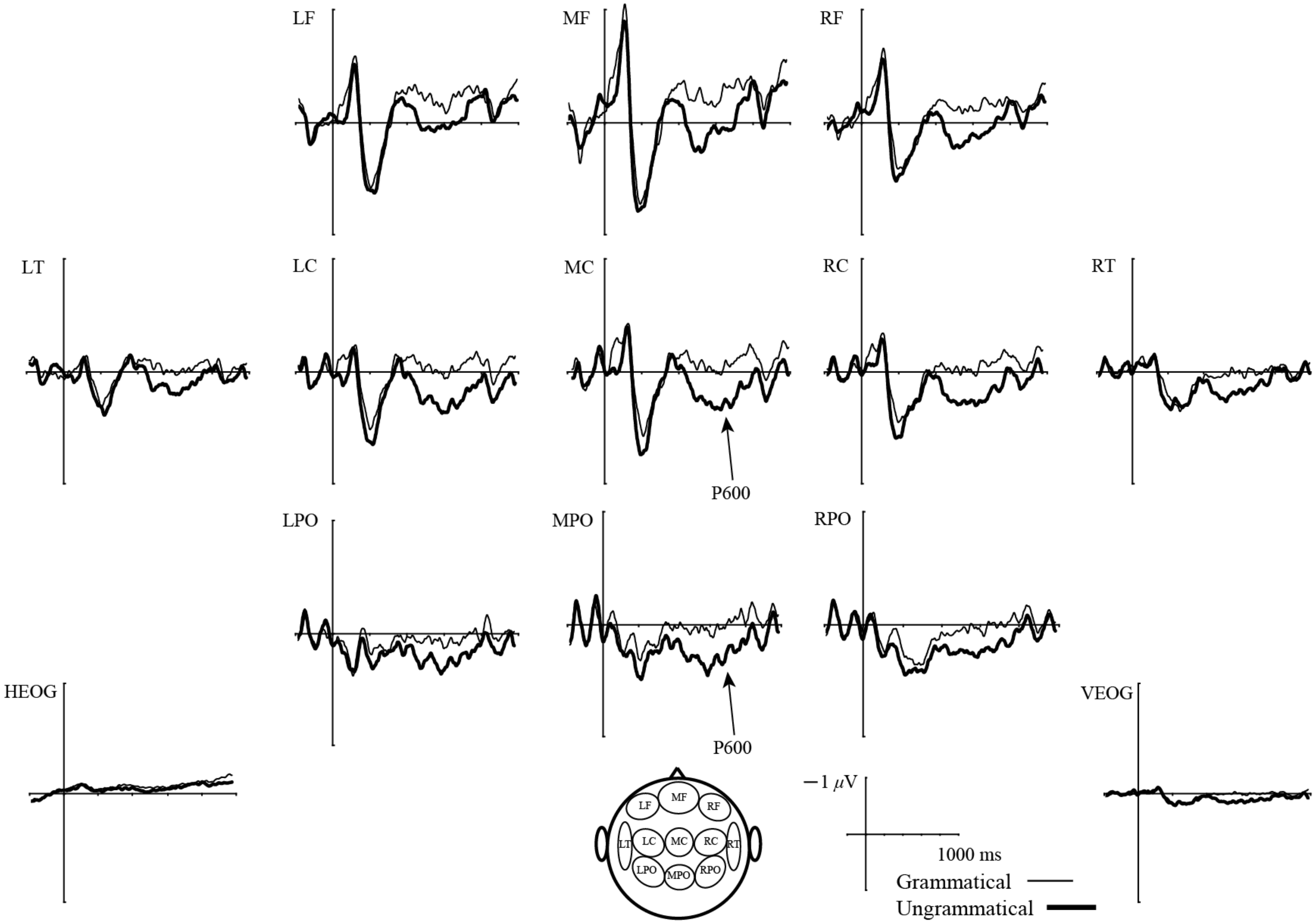


Figure 5.11. Grand averaged ERPs for the Present condition in EH, which were averaged across seven electrodes in each ROI.

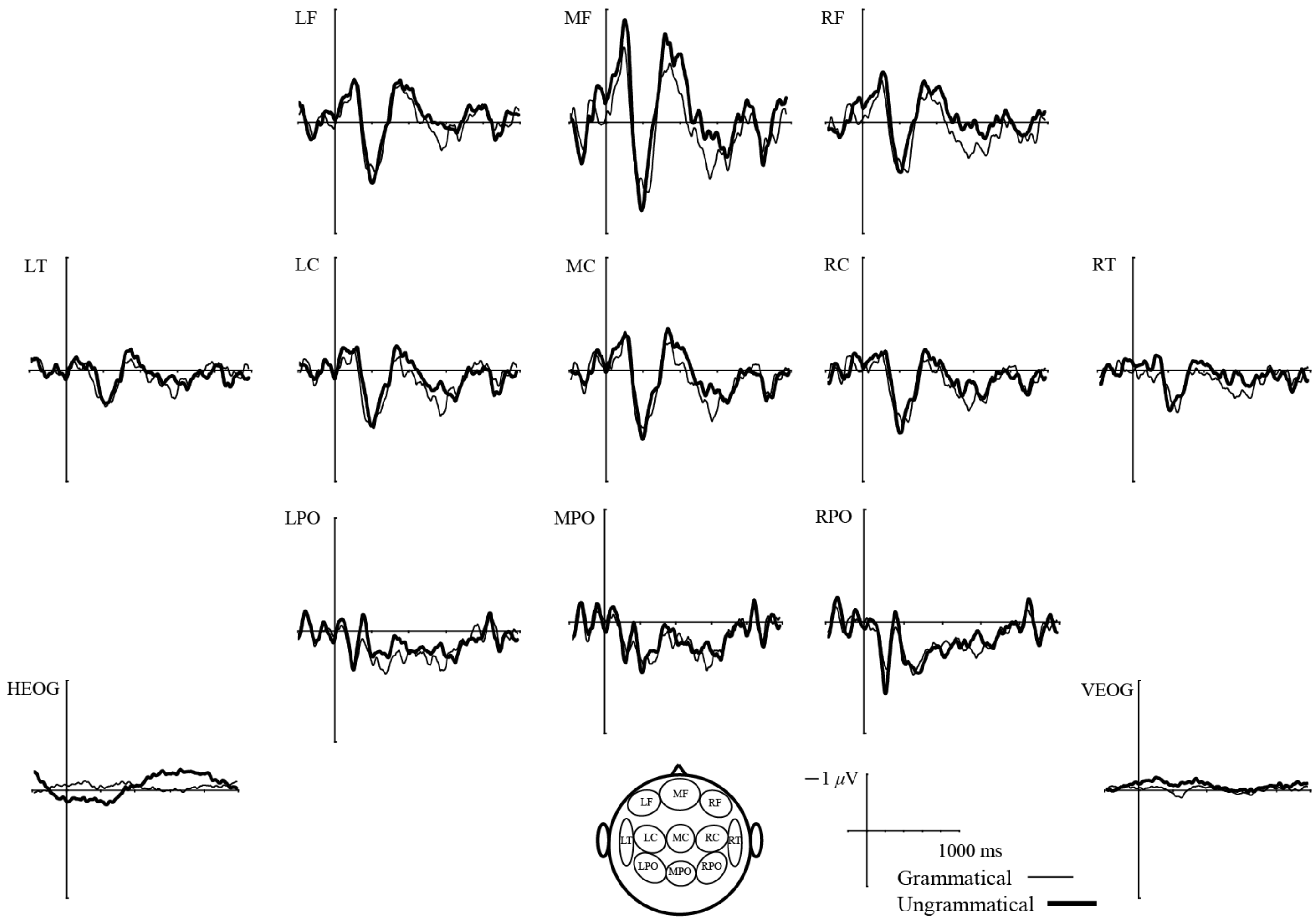


Figure 5.12. Grand averaged ERPs for the Present condition in EL, which were averaged across seven electrodes in each ROI.

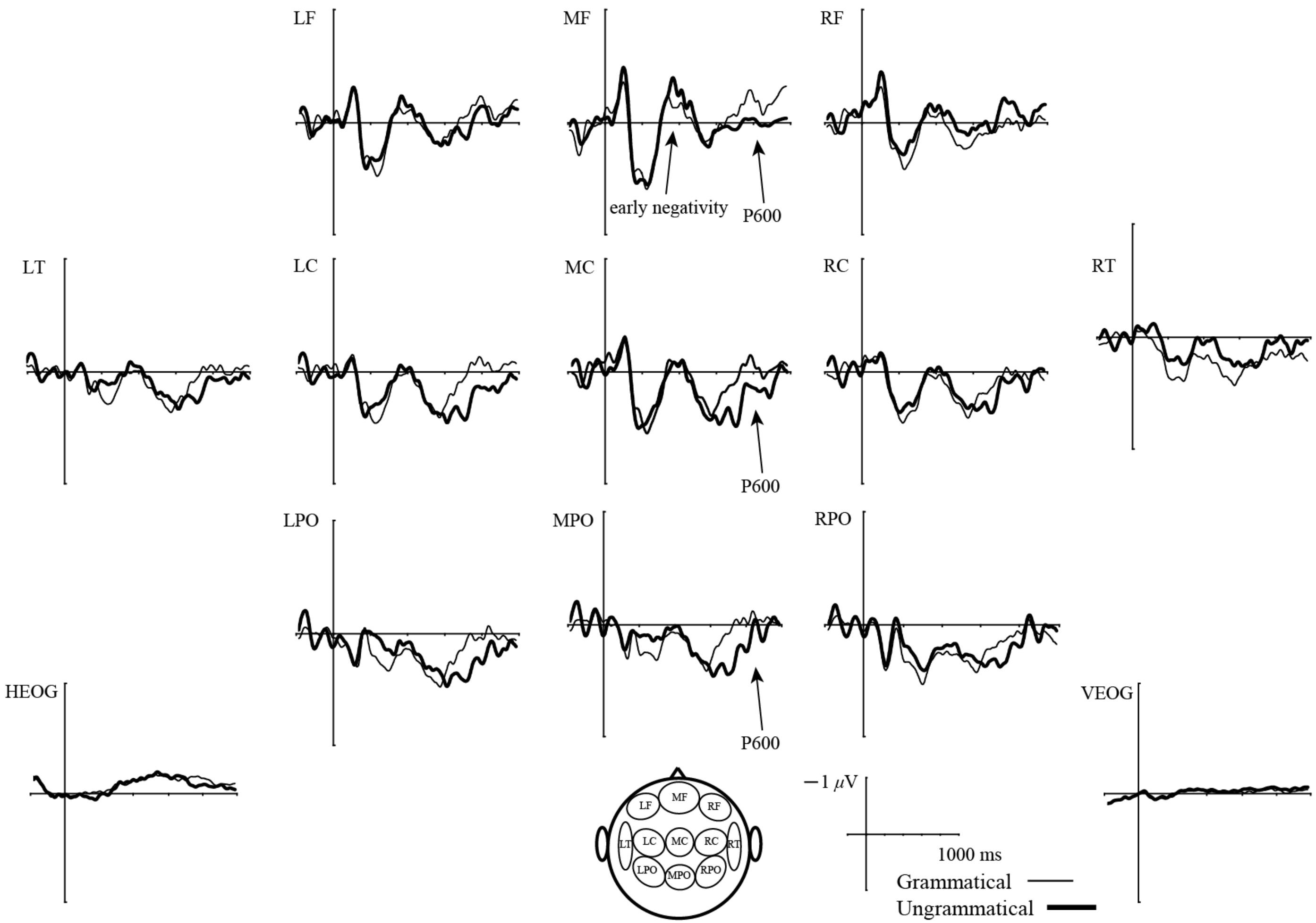


Figure 5.13. Grand averaged ERPs for the Present condition in LH, which were averaged across seven electrodes in each ROI.

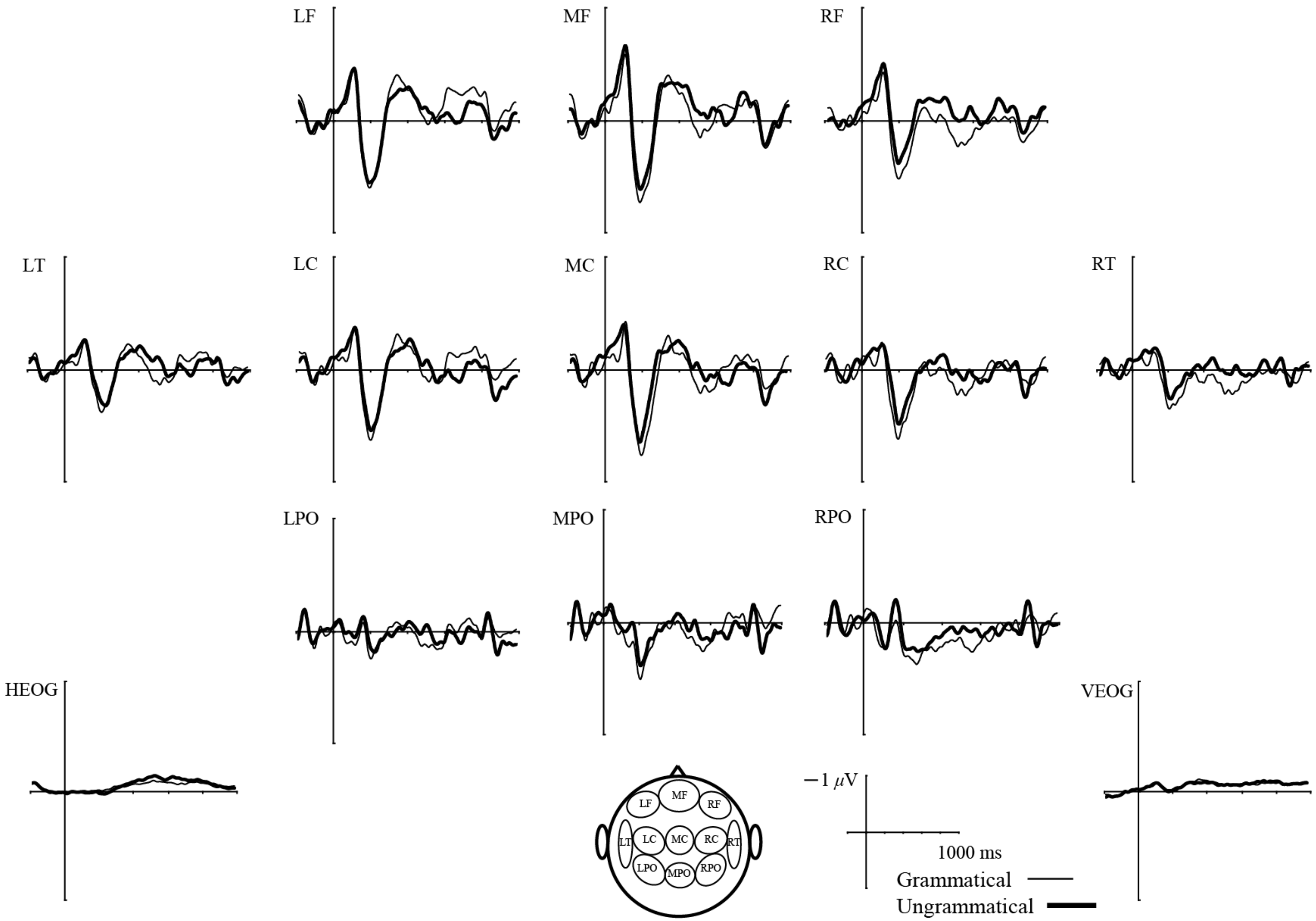


Figure 5.14. Grand averaged ERPs for the Present condition in LL, which were averaged across seven electrodes in each ROI.

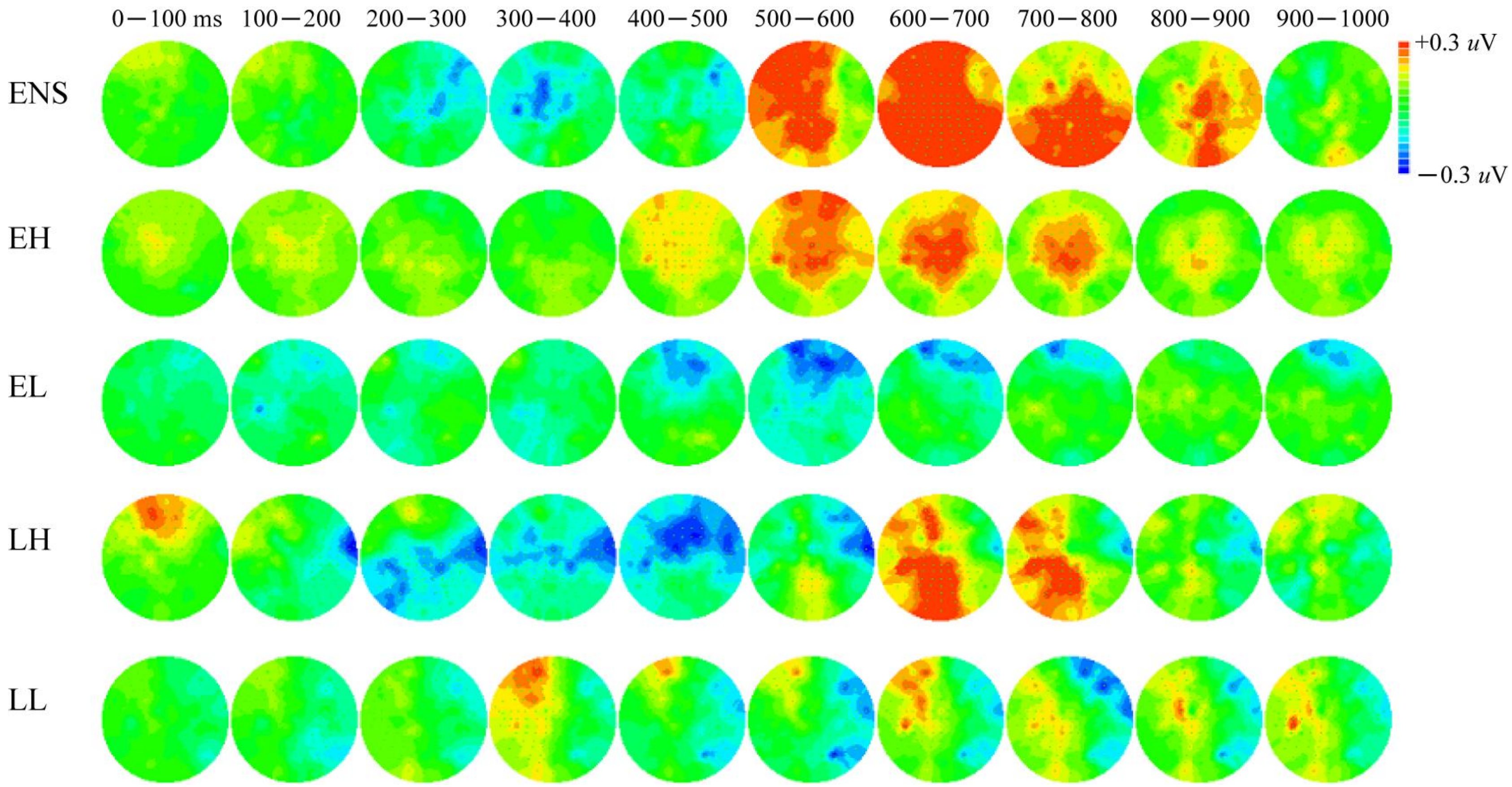


Figure 5.15. Scalp topographies for the Present condition in each group. Differences in potential values were computed by subtracting a control ERP from its violation condition (ungrammatical Present – grammatical Present).

Table 5.5

Summary of the Mean Amplitude Analysis of Variance for the Present Condition in the ENS Group

		Latency (ms)									
Factors	*df*	0–100	100–200	200–300	300–400	400–500	500–600	600–700	700–800	800–900	900–100
Lateral											
G	1, 16						4.96*	15.31**			
G × H	1, 16										
G × R	3, 48								4.02*		
G × H × R	3, 48										
Midline											
G	1, 16						7.90*	15.57**			
G × R	2, 32										

Note. G = Grammaticality (grammatical, ungrammatical); H = Hemisphere (left, right); R = ROI.
*p < .05; **p < .01.

Table 5.6

Summary of the Mean Amplitude Analysis of Variance for the Present Condition in the JLE Groups

		Latency (ms)									
Factor	*df*	0–100	100–200	200–300	300–400	400–500	500–600	600–700	700–800	800–900	900–100
Lateral											
G	1, 83										
G × A	1, 83					5.02*					
G × P	1, 83										
G × A × P	1, 83			4.21*	5.79*	8.15**	6.17*	5.64*			
G × H	1, 83										
G × H × A	1, 83										
G × H × P	1, 83										
G × H × A × P	1, 83										
G × R	3, 249										
G × R × A	3, 249										
G × R × P	3, 249										
G × R × A × P	3, 249										
G × H × R	3, 249										
G × H × R × A	3, 249										
G × H × R × P	3, 249										
G × H × R × A × P	3, 249										
Midline											
G	1, 83							5.62*			
G × A	1, 83										
G × P	1, 83						5.43*	5.57*			
G × A × P	1, 83					7.74**	4.78*				
G × R	2, 166								4.66*		
G × R × A	2, 166										
G × R × P	2, 166										
G × R × A × P	2, 166					5.81**	3.61*				

Note. G = Grammaticality (grammatical, ungrammatical); H = Hemisphere (left, right); R = ROI; A = Age (Early, Late); P = Proficiency (High, Low).
*p < .05; **p < .01

5.2.2.3. Group Effect in the Present Condition

To assess a group effect on the processing of the Present condition, the peak latency and amplitude of P600 at the midline site (500–800 ms) in the ENS and High groups were calculated (Figure 5.16). The peak latency and amplitude of the early negativity, however, were not calculated because of the apparent quantitative differences in the distribution and onset latency between the ENS group and LH (shorter onset latency [the ENS group: 400–450 ms; LH: 200–300 ms] and wider distribution in LH than in the ENS group). The peak latency of P600 was significantly longer in LH relative to the ENS group and EH, $F(2, 60) = 1.67$, $MSE = 0.57$, $p = .016$, and the peak amplitude was significantly reduced in the High groups relative to the ENS group, $F(2, 60) = 2.34$, $MSE = 0.36$, $p = .014$.

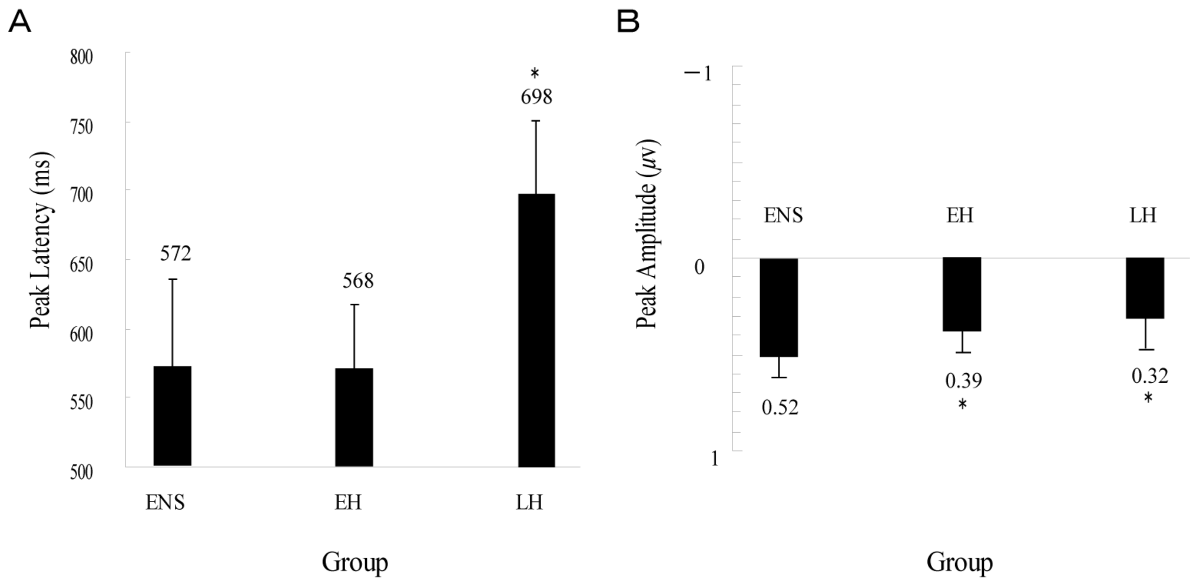


Figure 5.16. Group comparison of P600 at the midline site (500–800 ms) for the Present condition. The error bars represent standard errors in the figure. The values that differed from the ENS group are indicated (*$p < .05$). (A) Mean peak latency (ms). (B) Mean peak amplitude (μV).

5.2.3 Past Condition

Grand averaged ERPs for the Past condition in the ENS group, EH, EL, LH, and LL are shown in Figure 5.17, 5.18, 5.19, 5.20, and 5.21. The scalp topographies for the Past condition in each group are plotted in Figure 5.22. The results of the mean amplitude ANOVAs for the Past condition in the ENS and JLE groups are summarized in Tables 5.7 and 5.8, respectively.

According to visual inspection of the ERPs and the scalp topographies for the Past condition, it seems that the ungrammatical Past elicited a biphasic ERP pattern with negativity followed by a late positivity in the ENS group. In the JLE groups, a later positivity seems to have been elicited in EH, whereas a sustained component, which is not positivity but negativity, is apparently visible in EL and the Late groups.

5.2.3.1 Past Condition in the ENS Group

In the time window from 100 to 200 ms for ELAN and the time window from 300 to 500 ms for LAN, neither the main effect of Grammaticality nor the interaction by Grammaticality was significant at the lateral or midline sites, which was similar to the Present condition and suggested that neither ELAN nor LAN was elicited. Because of a visible negativity, additional ANOVAs were performed with each 50 ms time window between 300 and 500 ms after the stimulus. This analysis at the lateral sites (400–450 ms) revealed the significant main effect of Grammaticality, $F(1, 16) = 1.37$, $MSE = 0.31$, $p = .002$, and the significant interaction of Grammaticality × Hemisphere, $F(1, 16) = 4.23$, $MSE = 0.44$, $p = .014$, reflecting negativity at the left hemisphere.

In the time window from 500 to 800 ms for P600, the main effect of Grammaticality, $F(1, 16) = 18.11$, $MSE = 0.45$, $p = .001$, and the interaction of Grammaticality × Hemisphere × ROI, $F(3, 48) = 4.17$, $MSE = 0.01$, $p = .011$, were significant at the lateral sites (700–800 ms), reflecting positivity with a broad distribution at all ROIs (frontal, temporal, central, parietal occipital), and only the main effect of Grammaticality was significant at the midline site, $F(1, 16) = 22.24$, $MSE = 0.24$, $p < .001$. Thus, a late positivity was elicited with a broad distribution from 700 to 800 ms after the stimulus, which could be P600, but with an untypical distribution for P600.

These statistical findings indicated that the ungrammatical Past elicited a left lateralized negativity, which was followed by P600 in the ENS group.

5.2.3.2 Past Condition in the JLE Groups

In the time window from 100 to 200 ms for ELAN, neither the main effect of Grammaticality nor the interaction by Grammaticality was significant at the lateral or midline sites, which was similar to the ENS group and suggested that ELAN was not elicited in any of the JLE groups.

In the time window from 300 to 500 ms for LAN, the continuous significant main effect of Grammaticality was observed at the midline site, (300–400 ms): $F(1, 83) = 6.37$, $MSE = 0.38$, $p = .014$, and (400–500 ms): $F(1, 83) = 9.52$, $MSE = 0.44$, $p = .003$. At the lateral sites (400–500 ms), the main effect of Grammaticality, $F(1, 83) = 10.62$, $MSE = 1.02$, $p = .002$, and the interaction of Grammaticality × Age, $F(1, 83) = 5.26$, $MSE = 1.02$, $p = .024$, were significant, reflecting negativity in the Late groups, $F(1,43) = 10.20$, $MSE = 1.60$, $p = .003$. In short, negativity was elicited at the midline site from 300 to 500 ms after the stimulus in all of the JLE groups, and from 400 to 500 ms at the lateral sites in the Late groups. Negativity in the Late groups was continuously observed, suggesting that it must be further analyzed in the following windows in order to specify the component.

In the time window from 500 to 800 ms for P600, at the lateral sites (500–600 ms), the main effect of Grammaticality, $F(1, 83) = 6.81$, $MSE = 0.76$, $p = .011$, and the interaction of Grammaticality × Age, $F(1, 83) = 5.12$, $MSE = 0.76$, $p = .026$, were significant, which was due not to positivity, but rather to negativity, and had continued from 400 ms after the stimulus, in the Late groups, $F(1, 43) = 9.63$, $MSE = 0.95$, $p = .003$. The significant interaction of Grammaticality × Age continued at the lateral sites, (600–700 ms): $F(1, 83) = 7.05$, $MSE = 0.87$, $p = .009$, and (700–800 ms): $F(1, 83) = 5.74$, $MSE = 1.07$, $p = .019$, reflecting negativity in the Late groups, (600–700 ms): $F(1, 43) = 5.75$, $MSE = 1.24$, $p = .021$, and (700–800 ms): $F(1, 43) = 7.43$, $MSE = 1.38$, $p = .009$. Although the interaction of Grammaticality × Age was significant at the midline site (600–700 ms), $F(1, 83) = 4.39$, $MSE = 0.35$, $p = .039$, the main effect of Grammaticality did not reach significance in either the Early or Late groups.

These statistical findings indicated that the ungrammatical Past elicited a sustained negativity at the midline site from 300 to 500 ms after the stimulus in all of the JLE groups, which was also observed at the lateral sites from 400 to 800 ms only in the Late groups.

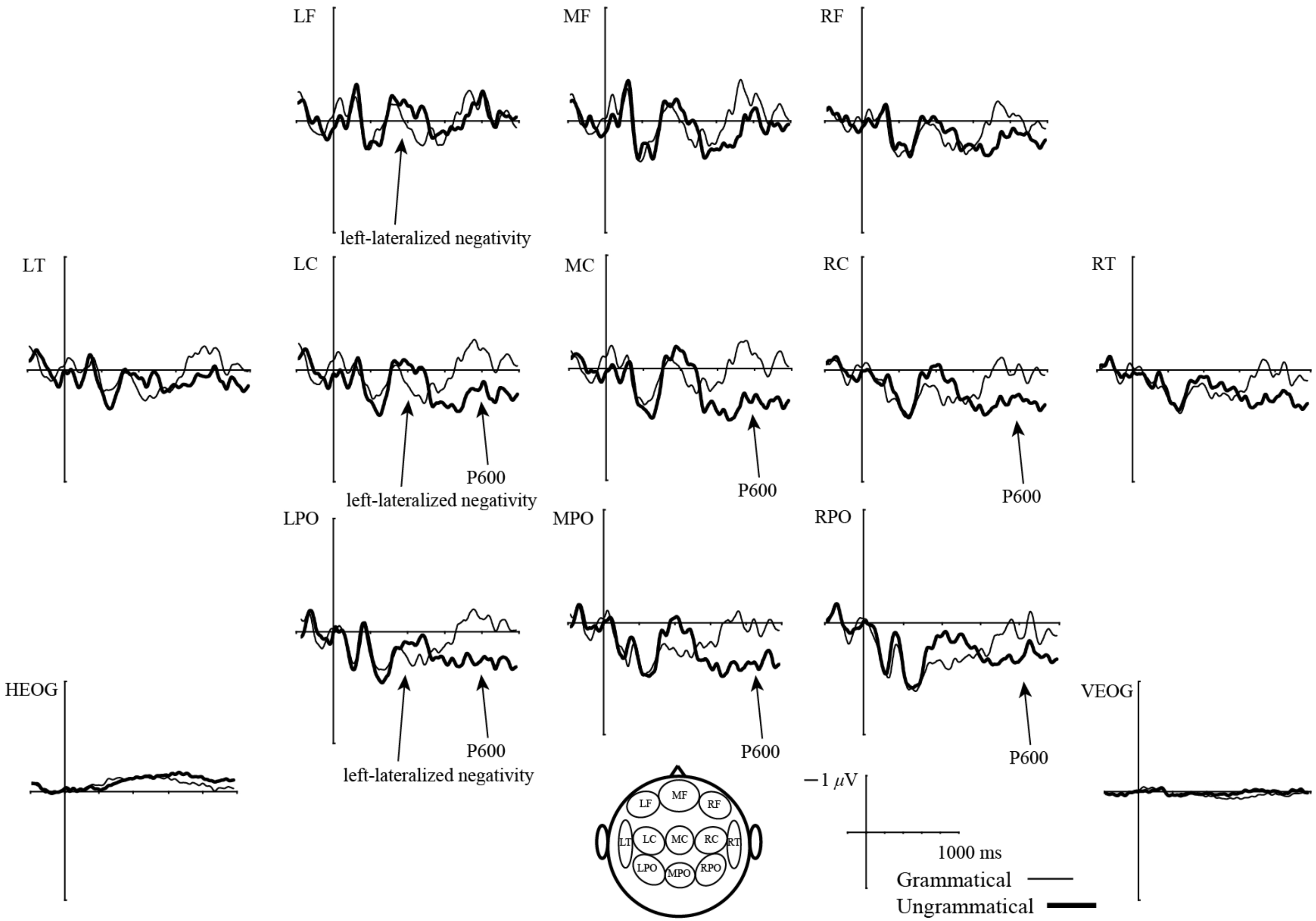


Figure 5.17. Grand averaged ERPs for the Past condition in the ENS group, which were averaged across seven electrodes in each ROI.

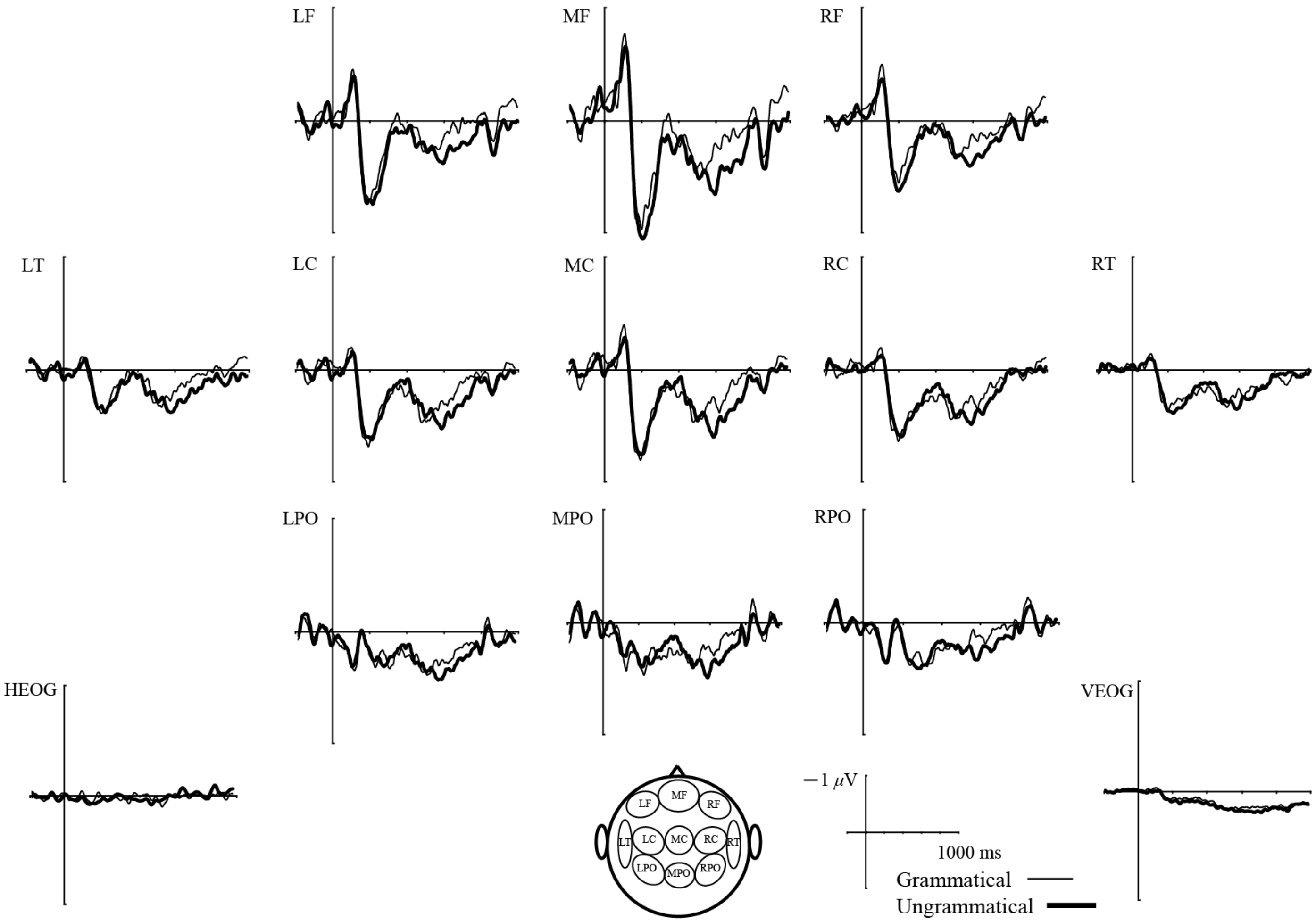


Figure 5.18. Grand averaged ERPs for the Past condition in EH, which were averaged across seven electrodes in each ROI.

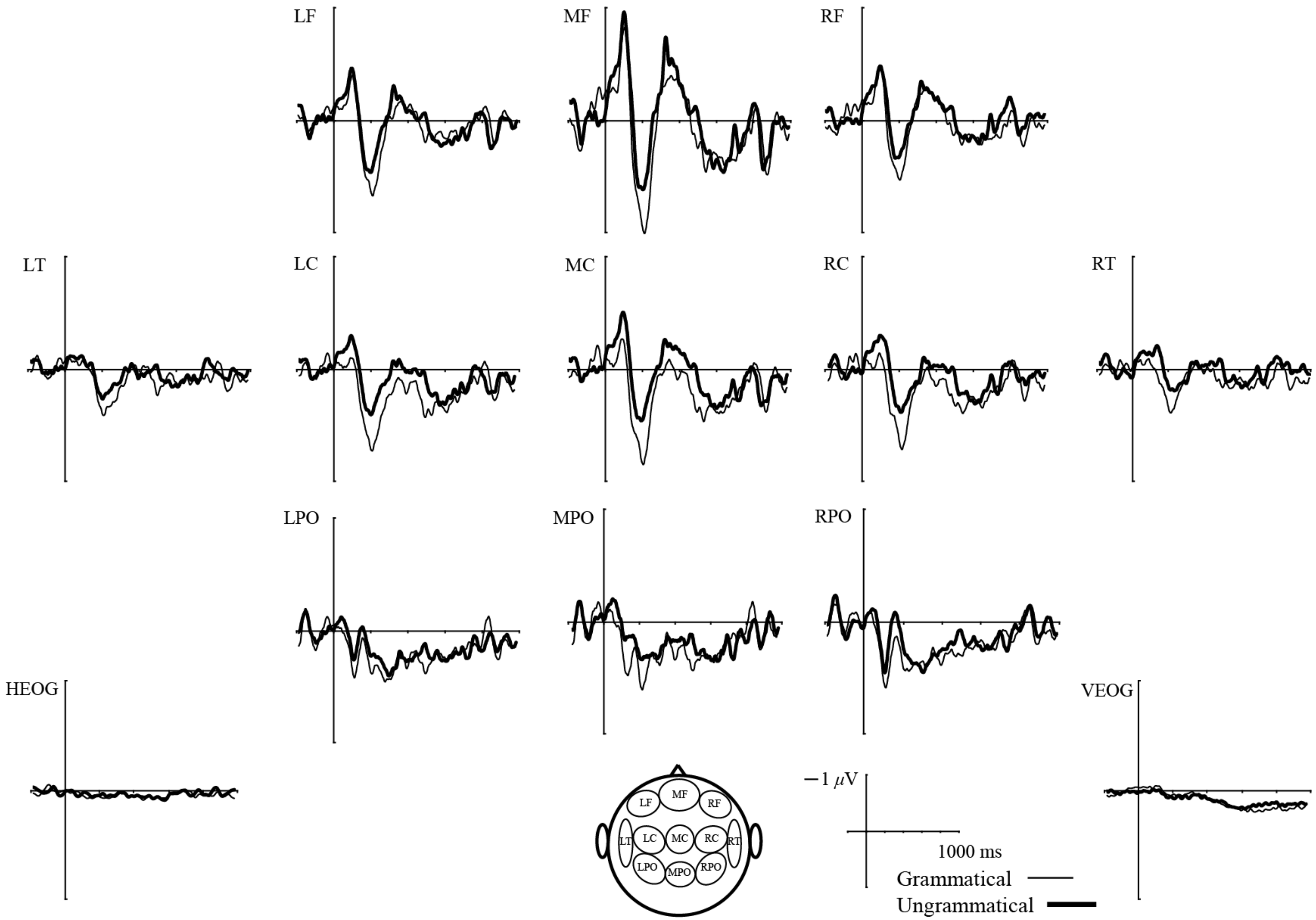


Figure 5.19. Grand averaged ERPs for the Past condition in EL, which were averaged across seven electrodes in each ROI.

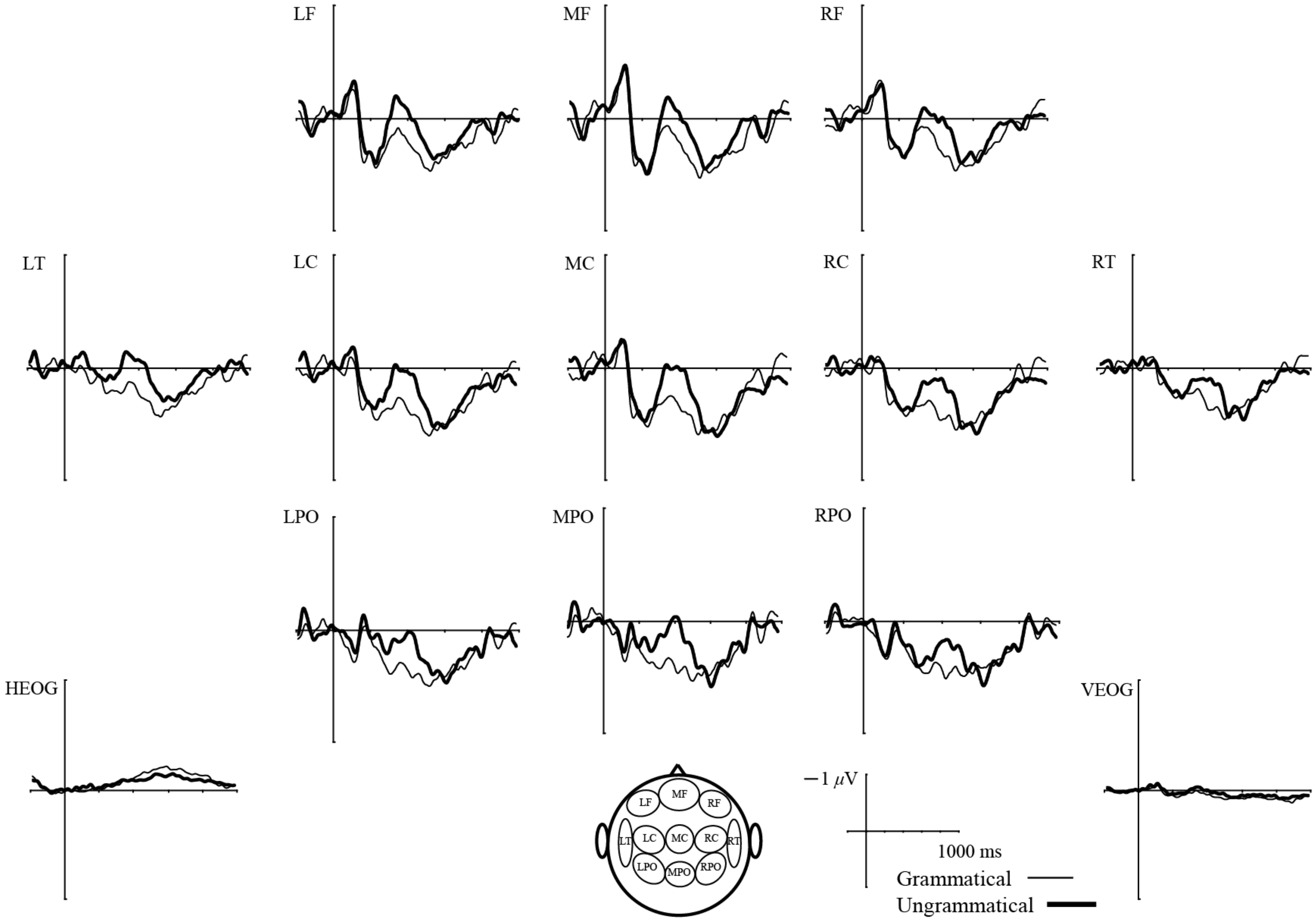


Figure 5.20. Grand averaged ERPs for the Past condition in LH, which were averaged across seven electrodes in each ROI.

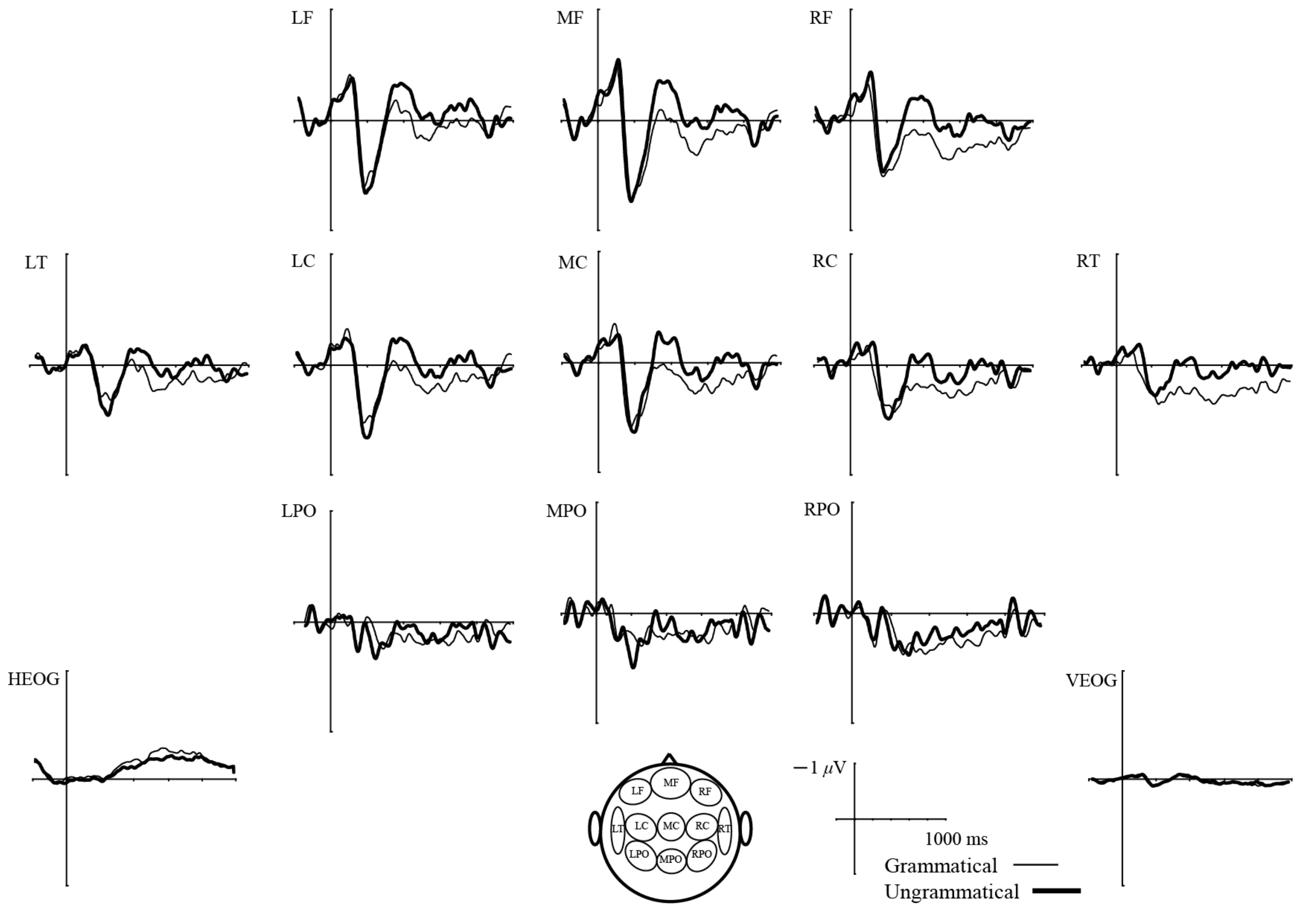


Figure 5.21. Grand averaged ERPs for the Past condition in LL, which were averaged across seven electrodes in each ROI.

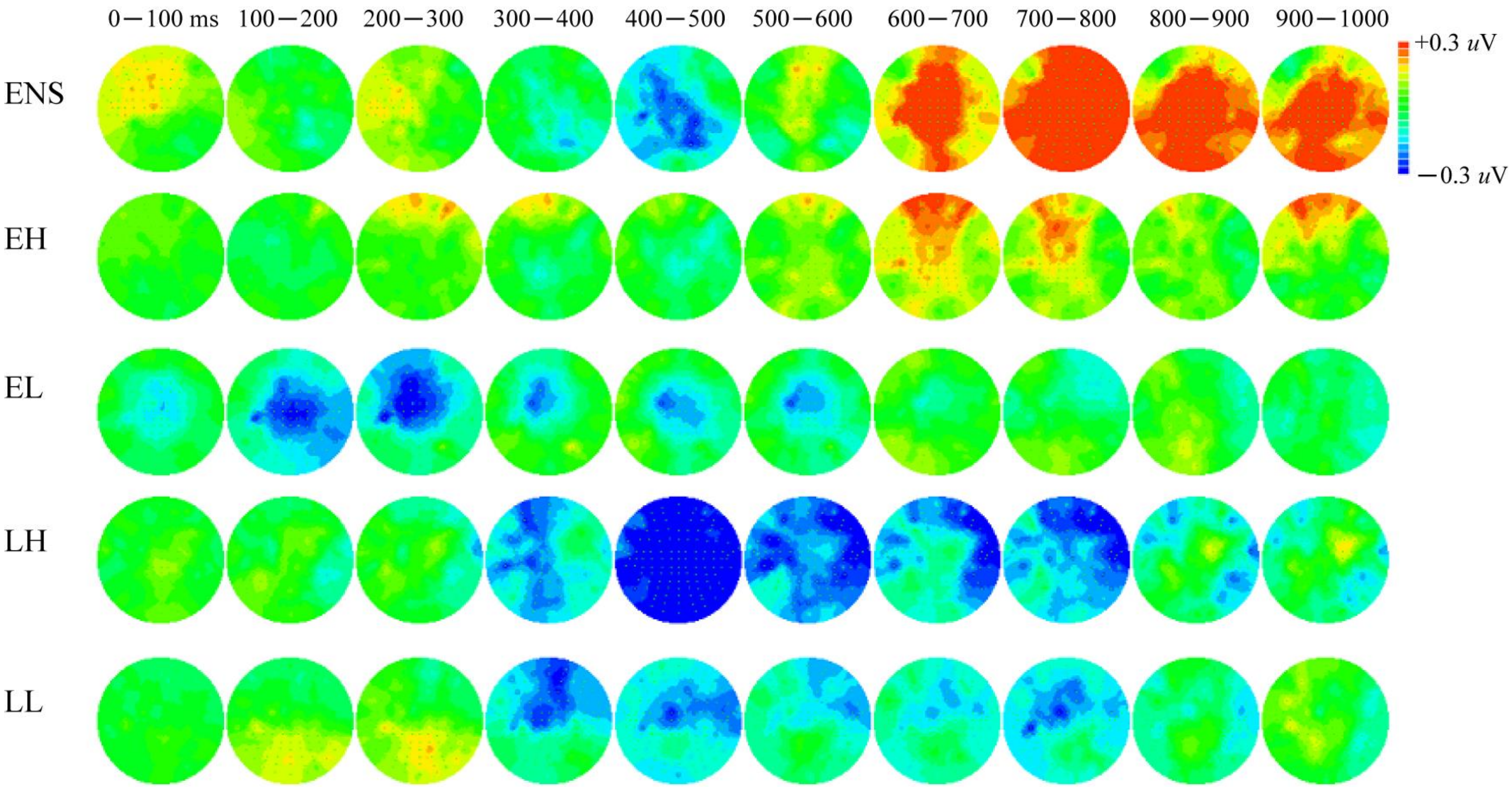


Figure 5.22. Scalp topographies for the Past condition in each group. Differences in potential values were computed by subtracting a control ERP from its violation condition (ungrammatical Past – grammatical Past).

Table 5.7

Summary of the Mean Amplitude Analysis of Variance for the Past Condition in the ENS Group

		Latency (ms)									
Factor	*df*	0–100	100–200	200–300	300–400	400–500	500–600	600–700	700–800	800–900	900–100
Lateral											
G	1, 16								18.11**	7.64*	5.80*
G × H	1, 16										
G × R	3, 48										
G × H × R	3, 48								4.17*		3.91*
Midline											
G	1, 16								22.24***	8.39*	6.44*
G × R	2, 32										

Note. G = Grammaticality (grammatical, ungrammatical); H = Hemisphere (left, right); R = ROI.
*p < .05; **p < .01; ***p < .001.

Table 5.8

Summary of the Mean Amplitude Analysis of Variance for the Past Condition in the JLE Groups

		Latency (ms)									
Factors	*df*	0–100	100–200	200–300	300–400	400–500	500–600	600–700	700–800	800–900	900–100
Lateral											
G	1, 83					10.62**	6.81*				
G × A	1, 83					5.26*	5.12*	7.05**	5.74*		
G × P	1, 83										
G × A × P	1, 83										
G × H	1, 83									5.90*	5.47*
G × H × A	1, 83										
G × H × P	1, 83										
G × H × A × P	1, 83										
G × R	3, 249										
G × R × A	3, 249										
G × R × P	3, 249										
G × R × A × P	3, 249										
G × H × R	3, 249										
G × H × R × A	3, 249										
G × H × R × P	3, 249										
G × H × R × A × P	3, 249										
Midline											
G	1, 83				6.37*	9.52**					
G × A	1, 83							4.39*			
G × P	1, 83										
G × A × P	1, 83										
G × R	2, 166										
G × R × A	2, 166										
G × R × P	2, 166										
G × R × A × P	2, 166										

Note. G = Grammaticality (grammatical, ungrammatical); H = Hemisphere (left, right); R = ROI.; A = Age (Early, Late); P = Proficiency (High, Low).
*p < .05; **p < .01.

5.2.3.3. Group Effect in the Past Condition

There were quantitative differences in the distribution of negativity between the ENS group and the JLE groups (earlier onset and wider distribution in the JLE groups than in the ENS group), and between the Early and Late groups (more sustained in the Late groups than in the Early groups). Due to the differences, neither the peak latency nor amplitude of the negativity were statistically compared.

Chapter 6 reviews the ERP results and provides interpretations and discussion comprehensively the three conditions, and suggestions for future research.

Chapter 6

Discussion

Chapter 6 provides discussion. After a brief review of the ERP results in section 6.1, section 6.2 interprets and discusses the results in each condition, and section 6.3 gives an overall discussion. Section 6.4 examines the three hypotheses in the present study, and then section 6.5 provides the implications of the present study each for English acquisition and processing in JLEs, English education in Japan, and ERP studies. Finally, section 6.6 explores avenues for future study.

6.1 Overview of the Results

Table 6.1 summarizes the ERP results

Table 6.1

Summary of the ERP Results

Group	Case	Present	Past
ENS	negativity with a broad distribution followed by P600	LAN followed by P600	a left lateralized negativity followed by P600
EH	negativity (reduced amplitude at the lateral sites relative to the ENS group [ENS: –0.38 *u*V; EH: –0.17 *u*V]) followed by P600 (reduced amplitude at the midline site relative to the ENS group [ENS: 0.72 *u*V; EH: 0.31 *u*V])	P600 (reduced amplitude at the midline site relative to the ENS group [ENS: 0.52 *u*V; EH: 0.39 *u*V])	negativity (not confirmed by visual inspection of ERPs or the scalp topographies)
EL	negativity (reduced amplitude at the lateral sites relative to the ENS group [ENS: –0.38 *u*V; EL: –0.09 *u*V]) followed by P600 (reduced amplitude at the midline site relative to the ENS group [ENS: 0.72 *u*V; EL: 0.33 *u*V])	N/A	negativity (earlier onset latency confirmed by visual inspection of the scalp topographies)
LH	negativity (reduced amplitude at the lateral sites relative to the ENS group [ENS: –0.38 *u*V; LH: –0.14 *u*V]) followed by P600 (reduced amplitude at the midline site relative to the ENS group [ENS: 0.72 *u*V; LH: 0.52 *u*V])	negativity (longer onset latency [ENS: 400–450 ms; LH: 200–300 ms] and wider distribution than the ENS group) followed by P600 (reduced amplitude at the midline site relative to the ENS group [ENS: 0.52 *u*V; LH: 0.32 *u*V]), and a longer peak latency than the ENS group and EH [ENS: 572 ms; EH: 568 ms; LH: 698 ms])	negativity (sustained and wider distribution than the ENS group that was distributed around the anterior part of the scalp, which was confirmed by visual inspection of the scalp topographies)
LL	negativity (reduced amplitude at the lateral sites relative to the ENS group [ENS: –0.38 *u*V; LL: –0.11 *u*V]) followed by P600 (reduced amplitude at the midline site relative to the ENS group [ENS: 0.72 *u*V; LL: 0.38 *u*V])	N/A	negativity (sustained and wider distribution than the ENS group, which was frontally distributed and confirmed by visual inspection of the scalp topographies)

6.2 Discussion in Each Condition

Section 6.2 interprets and discusses the results in each condition.

6.2.1 Case Condition

The ERP results for the Case condition showed a biphasic ERP pattern with an early negativity with a broad distribution followed by P600 in all of the JLE groups as well as in the ENS group.

6.2.1.1 Early Negativity

Regarding an early negativity elicited in the ENS group, negativity was not LAN but negativity with a broad distribution, which did not strictly replicate the results of previous studies (e.g., Coulson, King, & Kutas, 1998; Friederici & Frisch, 2000). This negativity, however, could be referred to as LAN, which is the indicator of morphosyntactic processing (Friederici, 2002), because of the latency and the appearance of P600 after negativity in response to morphosyntactic violations. Similarly, negativity in the JLE groups could be comparable to a bilateral anterior negativity, which has been observed for L2 morphosyntactic processing in late L2 learners with intermediate to high/near native-like L2 proficiency as an index of near native-like early automatic processing (Steinhauer et al, 2009), although the scalp distribution was not restricted to the anterior region of the scalp. The ERP results in the JLE groups suggested that the neural mechanisms underlying the processing of Case in English, i.e., the operation of Agree, which requires the uninterpretable Case feature [Case] of PRN, are not qualitatively different between the ENS and JLE groups, but qualitatively different between them as shown in the reduced amplitude of the early negativity at the lateral sites (ENS: –0.38 *u*V; EH: –0.17 *u*V; EL: –0.09 *u*V; LH: –0.14 *u*V; LL: –0.11 *u*V) and in that of the late positivity at the midline site (ENS: 0.72 *u*V; EH: 0.31 *u*V; EL: 0.33 *u*V; LH: 0.52 *u*V; LL: 0.38 *u*V) in the JLE groups relative to the ENS group. The processing was not qualitatively different among the JLE groups either, which follows that JLEs are able to process the uninterpretable Case feature [Case] of PRN regardless of the age of learning English or the English proficiency level. This tendency was also observed in the behavioral results, showing no group difference in the mean judgment accuracy for either the grammatical or ungrammatical Case.

6.2.1.2 Negativity/P600 in the JLE Groups

The ERP results in the JLE groups could be interpreted at least in the following two ways.

Firstly, the results reflected the degree of understanding or the acquisition of the operation of Agree for Case in the process of explicit L2 learning.

Secondly, the results support the full accessibility to UG position by the JLE groups. This argument is supported if native-like sensitivity to all of the three ungrammatical conditions is confirmed.

Secondly, the results reflected visual processing. It might be relatively easy to detect the ungrammatical Case because the ungrammaticality appeared not in inflectional morphology such as 3SG -*s* and past tense -*ed* but instead in PRNSs such as nominative *I* and accusative *me*. This argument is supported for the behavior results: The Late groups judged ungrammatical Case more accurately than the ungrammatical Present and Past, and the ENS group and LH judged the ungrammatical Case more accurately than the ungrammatical Past.

6.2.2 Present Condition

The ERP results for the Present condition in the ENS group showed a typical pattern for morphosyntactic processing, namely a biphasic ERP pattern with LAN followed by P600, and those in the JLE groups suggested the effect of the English proficiency level on the appearance of P600: P600 in EH and negativity with a broad distribution from 300 to 500 ms after the stimulus, which was followed by P600 in LH versus no ERP component in the Low groups.

6.2.2.1 ENS versus JLE

Negativity in LH reflected morphosyntactic processing, which was a function of LAN as elicited in the ENS group. Therefore, the ERP pattern, which was a biphasic ERP pattern, in LH corresponded with that in the ENS group. Despite the different ERP patterns in the ENS group and LH, the appearance of P600 without LAN in EH replicated the results found in high L2 learners in previous studies (Hahne, 2001; Rossi et al., 2006; Sabourin, 2003; Tokowicz & MacWhinney, 2005). These results implied that EH was able to perform the native-like mechanisms of the P600-indexed late controlled morphosyntactic processing, but morphosyntactic marking, which was supposed to be represented by the appearance of LAN, for subject-verb agreement was less crucial for the assignment of grammaticality in a given sentence in EH than in the ENS and LH groups[1]. It should be noted here that an early negative inflection was confirmed by visual inspection of ERPs and the scalp topographies at the frontal region in EH, which was, however, not statistically confirmed. Accordingly, the ERP results suggested that the neural mechanisms underlying the processing of subject-verb agreement in English, i.e., the operation of Agree, which requires uninterpretable φ-features [person][number] of T, interpretable tense feature [present] of T, and inflectional feature [Infl]of *v* are not qualitatively different between the ENS and High groups once their English proficiency reaches a higher level but are quantitatively different, as shown in the reduced amplitude of P600 at the midline site in EH and LH relative to the ENS group (ENS, 0.52 μV; EH, 0.39 μV; LH, 0.32 μV). In addition to P600, negativity in LH was quantitatively different in the onset peak latency (ENS,

[1] Friederici (2011) argued that “he likelihood of observing this effect [the presence/absence of LAN] increases with the amount of morphosyntactic marking in a given language” (p. 1381).

400–450 ms; LH, 200–300 ms) and in the distribution of negativity from the ENS group. In contrast to those in the High groups, the ERP results in the Low groups showed no ERP component, suggesting that the Low groups did not process the operation of Agree for subject-verb agreement in English. The results in the Low groups also replicated the results obtained for low L2 learners in previous studies (Hahne, 2001; Ojima et al., 2005).

The appearance of P600 was related to the behavioral results. The groups in which P600 was elicited (ENS, EH, and LH) judged the ungrammatical Present significantly more accurately than the groups in which P600 was not elicited (EL and LL).

6.2.2.2 Within the JLE Groups

There was an explicit difference in the ERP results between the High and Low groups in the appearance of P600: P600 in the High groups versus no ERP component in the Low groups. These findings showed the effect of the English proficiency level on the P600-indexed controlled morphosyntactic processing. The results in the High groups were not consistent with the findings of Wakabayashi et al. (2007), in which P600 was not observed in response to subject-verb disagreement in number in late JLEs. This inconsistency between the two ERP studies probably arose from the differences in the English proficiency levels in the JLE groups. The English proficiency levels in the Higher groups in the present study might have been higher than those in the JLEs in the study of Wakabayashi et al. (2007), and a higher English proficiency level would enable the appearance of P600 in the Higher groups in the present study[2].

Between the High groups, the peak latency of P600 was significantly longer in LH than in EH at the midline site (EH, 568 ms; LH, 698 ms), whereas the peak

[2] Wakabayashi (1997) has used a self-paced word-by-word reading task to show that advanced JLEs are sensitive to subject-verb disagreement in number, whereas intermediate JLEs are not.

amplitude of P600 was not different between the two groups. The longer peak latency of P600 in LH was not subject to the age of learning English, but it was thought to be attributed to an earlier process associated with the early negativity, which was elicited in LH but not in EH.

6.2.2.3 EH versus LH for Negativity

The critical question left for the Present condition was why the early negativity was elicited only in LH despite the English proficiency level, which was the same as that of the EH group. It is unreasonable to suggest that the *Oxford Placement Test* (UCLES, 2001) was not appropriate for the criterion for the adequate assessment of JLEs' English proficiency levels. This test is reliable and valid as it was developed by Oxford; therefore, its use has been widely accepted for assessing the English proficiency level of L2 learners (Hawkins & Chan, 1997; Hawkins & Liszka, 2003; Shibuya & Wakabayashi, 2008).

The next question was what factors affected the different results between the High groups other than the age of learning English. The survey conducted in the present study suggested two factors. One of the factors was the length of stay in an English-speaking country. The participants in LH had stayed there significantly longer than the other JLE groups[3] $F(3, 83) = 6.38$, $p = .001$. The other factor was self-rated English proficiency. The participants in EH subjectively rated their English proficiency as significantly higher in listening and speaking than in writing, $F(3, 66) = 7.34$, $MSE = .31$, $p = .001$, whereas those in LH rated in reading, $F(3, 83) = 7.13$, $MSE = 0.56$, $p < .001$, and writing, $F(3, 83) = 6.72$, $MSE = .71$, $p < .001$, higher than the other JLE groups but not in listening or speaking. These differences in superior skills affected the results. That is, the modality of the experiment in the present study was visual, which might have been more beneficial for LH than for EH. If the stimuli had been presented auditorily, then

[3] Ojima et al. (2005) also reported that LAN without P600 was elicited only in a higher English proficiency level group who had stayed in an English-speaking country significantly longer than a lower English proficiency level group.

the early negativity could have been elicited in EH in the same manner as it was elicited in the ENS group and LH for the visual stimuli. To clarify what caused the appearance of the early negativity in the High groups, further research is necessary, with the length of stay in an English-speaking country controlled for so that the groups are equal and with the use of not only visual stimuli but also auditory stimuli.

With respect to the skills, the differences in learning English styles between the High groups should be considered. The Early groups belonged to an activity group in which they had received basically only English sound inputs, and one of the purposes of the activity group was to acquire high English proficiency through the activity. The learning style did not correspond to what the Late groups had experienced (learning English basically through written English in a classroom setting). These preferential styles of learning English could have caused LH to explicitly learn the operation of Agree for subject-verb agreement, which in turn could have caused LH to process the knowledge of the operation implicitly. Thus, this difference in the preferential style of learning English could have affected their skills, and their skills in turn could be one of the factors that affected the appearance/lack of the early negativity in response to visual stimuli in the present study.

6.2.2.4 The Lack of P600 in the Low Groups

What caused the lack of P600 in the Low groups? There are some possibilities.

Firstly, the lack of P600 in the Low groups could have been subject to the effect of L1 transfer of the morphological representation system, as there is not the operation of Agree in Japanese, to subject-verb agreement in English. That is, the Low groups did not process the operation of Agree, which requires uninterpretable features that are not present in Japanese. The result in LL could be predicted by the RDH in that late L2 learners showed deficits in acquiring the uninterpretable features that are not present in their L1 and are not selected during the critical period. However, the result in EL was not predicted by the hypothesis because of their early start in learning English before the critical period.

Other than the effect of L1 transfer, the results could have been related to the nature of uninterpretable features, which was also suggested in the study of Wakabayashi et al. (2007). The features are optional features that must be specified by operations in numeration; therefore, JLEs have to learn the features in English. According to this argument, the Low groups might have not reached an English level high enough to process them.

Lastly, it has been suggested that the Low groups "do not process the number feature of subject" (Shibuya & Wakabayashi, 2008, p. 235). This suggestion was supported by the findings that the mean judgment accuracy for the ungrammatical Present in the Low groups was approximately 65%, which indicated that the Low groups could not understand the stimulus sentences, including the plurality of the subjects in the stimuli, completely. This argument must be further investigated through testing with several types of subjects in a sentence[4].

6.2.3 Past Condition

The ERP results for the Past condition showed a left lateralized negativity followed by P600 in the ENS group. These results were quantitatively different from those in the JLE groups; a sustained negativity at the midline site from 300 to 500 ms after the stimulus and at the lateral sites from 400 to 800 ms in the Late groups and only negativity at the midline site from 300 to 500 ms in the Early groups.

6.2.3.1 ENS versus JLE

Early left lateralized negativity elicited in the ENS group could be a sort of LAN, indicating that a biphasic pattern with LAN followed by P600 was elicited in the ENS

[4] See Shibuya and Wakabayashi (2008) in section 4.1 in chapter 4 for the related experimental paradigm.

group in response to the ungrammatical Past. In contrast to the biphasic pattern in the ENS group, the statistical output indicated that negativity, which was, however, not visibly confirmed, and the sustained negativity were elicited in the Early and Late groups, respectively, without P600. These results suggested that the neural mechanisms underlying the processing of past tense inflection in English were qualitatively different between the ENS and JLE groups. However, the JLE groups were surely sensitive to past tense inflection in English as shown by the appearance of negativity, and the sensitivity appeared to be qualitatively different from that in the ENS group. In addition, the ERP results for the Past condition in the JLE groups suggested that in spite of the same acceptability pattern for the stimulus sentences for subject-verb agreement and past tense inflection, which was shown in the behaviour results, for the Present and Past conditions, different neural mechanisms were involved in their processing.

6.2.3.2 Negativity in JLE

Then, what does the ERP pattern of negativity without P600 in the JLE groups represent? The alternative negative ERP components are N400 and negativity reflecting working memory.

First, negativity might be N400 in response to morphosyntactic violations in L2 learners. *Late* L2 learners with very *low* L2 proficiency might rely on explicit knowledge and compensatory strategies in response to morphosyntactic violations, resulting not in syntactic processing, but instead in N400-indexed semantic integration processing (Steinhauer, et al., 2009). In the present study, JLEs were not categorized as a group with *low* English proficiency in the High groups or as a group of *late* English learners in the Early group; therefore, negativity was not referred to as N400. The scalp topographies of negativity in the JLE groups did not correspond to those of N400 either.

Thus, it was assumed that negativity in the JLE groups could refer to the second component, which was negativity reflecting *working memory*. The widely distributed sustained negativity in the JLE groups was clearly different from the left lateralized negativity observed in the ENS group for the other conditions and from any of the negativities observed in the JLE groups for the Case and Present conditions. These findings indicated that this sustained negativity was not a reflection of morphosyntactic processing *per se* but of some type of general cognitive function. One of the candidates for this would be *working memory* for syntactic processing, which is widely observed in the processing of filler gap dependencies in the sentences with, for example, *wh*-movement and scrambling (Fiebach, Friederici, Müller, & von Cramon, 2002; Kluender & Kutas, 1993). Hagiwara, Soshi, Ishihara, and Imanaka (2007) observed a sustained anterior negativity and P600 in the pre-gap position under the long-scrambled condition (e.g., the position of *hisho-ga* in *kaiken-de bengoshi-o*$_i$ *shacho-wa hisho-ga t*$_i$ *sagashiteiru to itta:* "At the meeting, the president said that the secretary was looking for the lawyer") relative to the canonical condition (e.g., *kaiken-de shacho-wa hisho-ga bengoshi-o sagashiteiru to itta:* "At the meeting, the president said that the secretary was looking for the lawyer"). They have argued that the sustained anterior negativity reflects a cost of holding the scrambled elements (i.e., *bengoshi-o*) for sentence comprehension. Although the sentences for the Past condition did not involve any movement operations, a different type of dependency existed between the past tense ADVP and the V with the tense feature. In processing the sentences, the L2 parser of the JLEs at first recognized the constituent in the sentence's initial position as the past tense ADVP. While maintaining the past tense feature of ADVP, the parser simultaneously had to analyse the second phrase as the subject of the sentence. When encountering the third phrase, the parser identified it as V and checked its tense feature, past or present, with the past tense feature of the first ADVP. These processes are quite demanding for the L2 parser and require working memory[5]. The L1 parser of the ENS group, however,

[5] The frontal distribution of negativity that was typically observed in LL supported that this negativity was a reflection of working memory.

would manipulate these processes effortlessly and automatically, thus resulting in no need for working memory. Sustained negativity was not elicited for the Present condition in the JLE groups may be because the subject NP and the VP were adjacent to each other and the operation of Agree for subject-verb agreement occurred instantly when the parser encountered the V.

If negativity is a reflection of working memory, the Late groups require more working memory for the processing of past tense inflection in English than the Early groups, as shown through more sustained negativity in the Late groups. With respect to working memory, some studies reported that working memory capacity could be an indicator for predicting the achievement of L2 acquisition (Harrington & Sawyer, 1992). However, the present study found correlation between the appearance of negativity and not the English proficiency level but instead the age of learning English.

6.2.3.3 The Lack of P600 in the JLE Groups?

There was still a possibility of the appearance of P600 in the JLE groups, and this possibility has not been eliminated. P600 could have been occasionally elicited in later time windows than those used in the present study (i.e., the time window from 500 to 800 ms after the stimulus). A late positive inflection was confirmed by visual inspection of ERPs and the scalp topographies at the frontal and central regions in EH, but this was not statistically confirmed. Similarly, close observations of ERPs and the scalp topographies in LH also revealed a very slight positivity at the central region. If P600 had been in fact elicited in later time windows in the JLE groups, negativity in the JLE groups could be referred to as a type of negativity (LAN) for morphosyntactic processing. If this was the case, the neural mechanisms underlying the processing of past tense inflection in English would not be qualitatively different between the ENS and JLE groups but quantitatively different, as shown in the quantitatively different latencies, amplitudes, and distributions of negativity and P600.

This possibility of the appearance of P600 in the JLE groups can be tested by conducting an experiment with a longer stimulus onset asynchrony (SOA) (more than 1000), which the present study employed, or with the placement of a critical word at the end of a sentence so that the later time window could be analysed.

6.3 Accessibility to UG

Because the ERP results for the Case and Present conditions did not show a qualitative difference between the ENS and High groups, we reached the conclusion that the neural mechanisms underlying the processing of Case and subject-verb agreement in English, namely the operation of Agree, were not qualitatively different between JLEs and ENS once their English proficiency reached a higher level, regardless of the age of learning English. These results reflect the degree of understanding or the acquiring of the operation of Agree for Case and subject-verb agreement in the process of explicit L2 learning. However, because of the observation of the native-like brain activities shown in the ERP results, we suggest that L2 learners' grammar was constrained by UG, which then supported the full access to the UG position. These results were consistent with the findings of a recent study of syntactic processing in JLEs using fMRI, which is conducted by Yusa et al. (2011)[6] and supports the view that both nature (UG) and nurture (instruction) cooperate together in acquiring and processing the L2.

If we assumed UG-constrained L2 acquisition and processing, the present study should have obtained the same behavioral and ERP results across the three conditions. The results, however, showed that this was not the case. For the Tense condition sustained negativity was observed in the Low groups. The sustained negativity was not elicited for the Case and Present conditions in the JLE group, which may be because the

[6] See chapter 3 for further details.

critical word PRN and the VP, and the subject NP and the critical word VP, respectively, in the stimulus sentences were adjacent to each other and that the operation of Agree for Case and subject-verb agreement occurred instantly when the parser encountered the V. Accordingly, it is suggested that the general cognitive function associated with working memory seemed to be more predominantly involved than L2 morphosyntactic processing in a certain aspect of L2 processing. In addition, a biphasic ERP pattern was observed for the Case condition in the Low groups as well as in the ENS and High groups could be related to the difference in visual processing. As mentioned in the earlier section, it might be relatively easy to detect ungrammatical Case because the ungrammaticality appears not in inflectional morphology such as 3SG *-s* and past tense *-ed* but in instead distinctive Case particles such as nominative *I* and accusative *me*. This argument is supported for the interpretation of the difference in the behavior and ERP results between the Case and Present conditions.

As for the stages of the UG-constrained L2 language acquisition and processing, it was suggested that, in the initial state of English acquisition, functional categories that are present in English but not present in Japanese are set as the Japanese setting (i.e., no Agree/morphological merger). In the later stage, however, the functional categories could be reset to the English setting (i.e., Agree), and, thereafter, JLEs are able to perform the native-like processing in the steady state. This successful acquisition and processing in the steady state could be accomplished under the requirement that JLEs reach a higher English proficiency level. To provide concrete evidence in support of these points, the present study showed that the Low groups did not process the operation of Agree for the Present condition, as shown by the absence of ERP component, because they might not have reached an English level high enough to process the operation that is not present in Japanese. However, the High groups were able to process the operation, as shown by the appearance of the elicited ERP component (P600), because they had reached an English proficiency level high enough to process it.

6.4 Hypothesis Testing

The present study proposed three hypotheses. Hypotheses 1, 2, and 3 were proposed in terms of the effects of the age of L2 acquisition (the age of learning English), L2 proficiency level (the English proficiency level), and L1 transfer, respectively.

Among the three effects, the effect of the English proficiency level, which was apparent for the Present condition, on the processing of subject-verb agreement in English was most clear in both the behavioral and ERP results: P600 in EH and negativity with a broad distribution from 300 to 500 ms after the stimulus followed by P600 in LH versus no ERP component in the Low groups. This successful acquisition and processing have also been constrained by L1 transfer of the morphological representation system, i.e., the operation of Agree, because the system does not present in Japanese. Consequently, these findings showed that L2 acquisition and the neural mechanisms underlying L2 morphosyntactic processing were affected by the L2 proficiency level (Hypothesis 2) and L1 transfer (Hypothesis 3).

The effect of the age of learning English was observed for the Past condition: early negativity in the Early groups versus sustained negativity in the Late groups. Given that sustained negativity reflects working memory, one can conclude that cognitive function associated with working memory was more predominantly involved than L2 morphosyntactic processing in a certain aspect of L2 processing, which was affected by the age of learning English.

Remember the three factors involved in the development of language insisted by Chomsky (2007); UG, external data, and principles not specific to FL. In the case of the present study, L1 transfer would be an aspect of external data, and the cognitive function associated with working memory could belong to the third factor, principles not specific to FL.

6.5 Implications

The present study has important implications each for English acquisition and processing, English education in Japan, and ERP studies.

Because the results for the Case and Present conditions in the High groups suggested that JLEs who have achieved higher English proficiency levels were able to process the operation of Agree, which requires uninterpretable features, the present study did not support the RDH. Regarding the MSIH, which predicts the separation of syntactic representations from their phonological exponents in L2 learners regardless of the L2 acquisition age or L2 proficiency level, no evidence was found to support the hypothesis completely either because visual presentation, and not auditory presentation, of stimuli was employed in the present study.

Then, what are the pedagogical implications for English education in Japan, where English is not a L2, but instead a foreign language? With the consideration of the L1 transfer of the morphological representation system, the task in detecting the linguistic differences especially in the morphological representation system between English and Japanese will be effective for JLEs with low English proficiency. One of the kinds of task goes to developing compensatory strategies[7] for the difficulties in the morphological representations. In particular, the results from the present study suggest the effectiveness of teaching the strategies for representing the morphology which is present in English but is not in Japanese, for example for the morphological representations of subject-verb agreement, by enouncing mapping syntactic representations on the phonological exponents: the agreement marker *-(e)s* of regular Vs can be pronounced /-*z*/, /-*s*/, or /-*iz*/, depending on the final sound of the verb form.

Lastly, the present ERP study represented the dictation between qualitative and quantitative differences in the sensitivity to English morphosyntactic violations, which were obscured in the behavioral results. Although the judgment accuracy in the Present

[7] See footnote 6 in chapter 3 for further details.

and Past conditions showed no difference between the ENS and High groups, the sensitivity to the conditions was represented differently in the ERP results according to the conditions. The ERP results revealed that the sensitivity to the Present condition was not qualitatively different between the ENS and High groups, as P600 elicited in the groups indicated, whereas the sensitivity to the Past condition seemed to be qualitatively different between them, as negativity elicited only in the JLE groups indicated. In addition to the differences between the ENS and High groups, the ERP results for the Present and Past conditions showed quantitative differences between the High groups as indicated by the early negativity elicited for the Present condition and the more sustained negativity elicited for the Past condition in LH indicated. Therefore, the present study suggested caution when interpreting native-like performance as evidence that there are no qualitative differences in the processing between native speakers and L2 learners and when interpreting the same performance as evidence that there are no differences in the processing among groups of L2 learners in only one type of behavioral results.

6.6 Limitations

The present study focused on a question “why L2 learners make errors,” investigating the neural mechanisms underlying English morphosyntactic processing in JLEs using ERPs in terms of the effects of the age of L2 acquisition (the age of learning English), L2 proficiency level (the English proficiency level), and L1 transfer. The present study clarified the effects of the English proficiency level and L1 transfer of the morphological representation system, and also suggests that the general cognitive function associated with working memory seemed to be more predominantly involved than L2 morphosyntactic processing in a certain aspect of L2 processing, which could be affected by the age of L2 acquisition.

Firstly, with regards to the properties of the participants, the present study did not completely exclude the factors which might affect English acquisition and processing in JLEs: The High groups were homogeneous with respect to the English proficiency level, but were not with respect to the length of stay in an English speaking country and the self-rated English proficiency in listening, reading, speaking, and writing skills. These factors might have affected the results for the Present condition, showing the early negativity only in LH. In order to investigate the effect of the English proficiency level on English processing more strictly, these factors should be controlled. In addition, not only High and Low groups, but also an Intermediate group could be included for a close investigation of a developmental stage of L2 acquisition and processing.

Next, due to the restrictions on the materials for the Present condition[8], the present study used only 3rd-person plural-number regular Ns for the subject DPs, in order to test JLEs' sensitivities to subject-verb disagreement only in number in English. Because subject-verb agreement in English is applied by the operation of Agree between uninterpretable φ-features [person][number] of T and interpretable φ-features [person][singular] of PRN/DP, it would be reasonable to employ the stimuli which can test subject-verb disagreement not only in number but also in person and in both person and number.

Regarding the experiment paradigm, the qualitative and quantitative differences in English processing between the ENS and JLEs groups should have been taken into account: Due to the overestimation of the differences, the possibility of appearance of P600 for the Past condition in the JLE groups could not be eliminated. This possibility of the appearance of P600 in the JLE groups can be tested by conducting an experiment with a longer SOA (more than 1000), which the present study employed, or with the placement of a critical word at the end of a sentence so that the later time window could be analyzed.

[8] See section 4.5.2.2 in chapter 4 for the restrictions.

Lastly, because the present study underestimated the JLEs' English proficiency in listening beforehand, the stimuli were presented visually. If the stimuli had been presented auditorily, then different results could have possibly been observed, especially in the High groups for the Present condition, as suggested in the earlier section. Moreover, the auditory presentation could test the MSIH more strictly because the hypothesis predicts the separation of syntactic representations from their phonological exponents. In case of auditory presentation, however, JLEs with low English proficiency may not be able to hear the stimuli. If the results for auditory presentation showed no ERP component, then it would be ambiguous whether the results reflect a lack of linguistic or sensory processing (i.e., no capability of listening to stimuli in English).These limitations are left for further investigation.

Section 7, the last chapter, summarizes the previous chapters, and makes some concluding remarks on English morphosyntactic processing in L2 learners grammars.

Chapter 7
Conclusion

Chapter 7 summarizes the previous chapters and concludes the dissertation. The dissertation aimed to investigate the neural mechanisms underlying English morphosyntactic processing in Case, Present (subject-verb agreement), and Past (past tense inflection) in JLEs using ERPs in terms of the effects of the age of L2 acquisition (the age of learning English), L2 proficiency level (the English proficiency level), and L1 transfer.

7.1 Summary of Chapters

Chapter 1 represented the theoretical background of the dissertation, that is, the theory of UG. UG has been regarded as a mental organ, and hence it is one of the factors involved in the development of language from the viewpoint of evolutional biology (Chomsky, 2007). The key argument in the theory for the dissertation investigating L2 processing was that parametric variations among languages are assumed to be associated with the properties of functional categories in UG, and therefore language learning is believed to involve the setting of functional categories. Although UG has been supposed to operate for L1 acquisition, it is still controversial whether or not the course of L2 acquisition is identical in nature to that of L1 acquisition, and what factors cause the difference between L1 and L2 acquisition. Taking into consideration that human beings are able to command multiple languages, it is a matter of great importance to investigate the mechanisms of L2 acquisition as well as those of L1 acquisition for exploring the nature of FL. Accordingly, the dissertation outlined the various positions taken in the L2 literature on UG in L2 acquisition in chapter 2.

Chapter 2 introduced research on L2 acquisition. This chapter started with an introduction of competing hypotheses of L2 acquisition within the framework of the MP.

The hypotheses were categorized mainly based on the accessibility to UG: full access, partial access, and no access. Among the hypotheses, two main perspectives to account for L2 learners' morphological variability were introduced, and studies of L2 acquisition based on each of the hypotheses were critically evaluated. The first perspective is the MSIH, which involves the full access to UG position, predicting that L2 learners' morphological variability is not a competence problem but rather a performance problem connecting the phonological forms with syntactic representations in speech production. The other perspective is the RDH, which involves the partial access to UG position, predicting that L2 learners' morphological variability is due to a permanent deficiency at the computation level in acquiring certain uninterpretable features of functional categories (not present in L1) rather than due to performance errors.

Chapter 3 reviewed studies of language processing using neurophysiological methods, mainly using ERPs, one of the neurophysiological techniques to explore cognitive processes in the brain. In chapter 3, ERP studies of language processing in native speakers were reviewed first, introducing four typical ERP components, that is, N400, ELAN, LAN, and P600. Then, ERP studies of L2 processing in bilinguals and L2 learners were systematically reviewed in terms of the effects of the age of L2 acquisition, L2 proficiency level, and L1 transfer. After that, developmental stages of L2 morphosyntactic processing in late L2 learners as indexed by ERP components are introduced. According to the stages, the expected sequence of the ERP component for L2 morphosyntactic processing in late L2 learners with higher L2 proficiency levels becomes is N400 → N400 + delayed/reduced P600 → earlier/larger P600 → anterior negativity + P600 → LAN + P600 with a quantitative difference across the stages (from delayed/reduced/wider component on the earlier stages to the native-like component in the later stages). Finally, some fMRI studies of L2 processing in bilinguals and L2 learners were also reviewed. Although both the ERP and fMRI studies have obtained inconsistent results for L2 processing, especially for L2 morphosyntactic processing, the results suggest that L2 processing is quantitatively or qualitatively different from L1 processing, and that L2 processing might be modulated by many factors such as the age of L2 acquisition, L2 proficiency level, and L1 transfer.

Chapter 4 presented the experiment using ERPs. In order to assess the effect of the age of L2 acquisition, JLEs were divided into two groups, Early or Late, based on the age of learning English, and then each group was subdivided into two groups to assess the effect of L2 proficiency level, High or Low, assessed by an English proficiency test. Therefore, there were four JLE groups: Early-High (EH), Early-Low (EL), Late-High (LH), and Late-Low (LL). The materials, which were visually presented word by word in the center of a computer screen, consisted of English stimuli for the following three conditions in order to assess the effect of L1 transfer: Case, Present (subject-verb agreement), and Past (past tense inflection). All of the conditions show the linguistic differences in the morphological representation system between English and Japanese.

Chapter 5 reported the behavioral and ERP results for each condition. Firstly, the ungrammatical Case elicited an early negativity with a broad distribution followed by P600 in the ENS group, and an early negativity with a broad distribution followed by P600 with different time windows according to the JLE groups. That tendency was also observed in the behavioral results, showing no qualitative group difference in the mean judgment accuracy for the grammatical and ungrammatical Case. For the Present condition, the second condition, a biphasic ERP pattern with LAN followed by P600 was elicited in the ENS group. The ERP results in the JLE groups for the Present condition showed the effect of the English proficiency level: P600 in EH and negativity with a broad distribution from 300 to 500 ms after the stimulus followed by P600 in LH versus no ERP component in the Low groups. For the Present condition, the appearance of P600 was related to the behavioral results. The groups in which P600 was elicited (ENS, EH, and LH) judged the ungrammatical Present significantly more accurately than the groups in which P600 was not elicited (EL and LL). For the last condition, the Past condition, the ungrammatical Past elicited a left lateralized negativity followed by P600 in the ENS group, sustained negativity at the midline site from 300 to 500 ms after the stimulus and at the lateral sites from 400 to 800 ms in the Late groups, and only negativity at the midline site from 300 to 500 ms in the Early groups. The behavioral results for the Past condition were equivalent to those for the Present condition: the ENS and High groups judged the ungrammatical Past significantly more accurately than the Low groups.

Chapter 6 reviewed the ERP results and provided the interpretations and discussions comprehensively across the three conditions. The present study clarified the effects of the English proficiency level and L1 transfer of the morphological representation system, and also suggests that the general cognitive function associated with working memory seemed to be more predominantly involved than L2 morphosyntactic processing in a certain aspect of L2 processing, which could be affected by the age of learning English. Because of the observation of the native-like brain activities shown in the ERP results, we suggest that L2 learners' grammar was constrained by UG. Accordingly, the present study supports full accessibility to UG position, showing no evidence to support the RDH.

7.2 Conclusion

Using ERP components as indices, the present study investigated the neural mechanisms underlying English morphosyntactic processing in JLEs from the aspect of the effects of the age of learning English, the English proficiency level, and L1 transfer of the morphological representation system. The findings suggested that JLEs were able to acquire and process the operation of Agree in English, and the English proficiency level and L1 transfer could have effects on English morphosyntactic processing in JLEs.

In addition, the present study suggested that the general cognitive function associated with working memory seemed to be more predominantly involved than L2 morphosyntactic processing in a certain aspect of L2 processing. This cognitive function of working memory could belong to a third factor which, Chomsky (2007) insists, is one of the factors involved in the development of language along with UG and external data from the view point of evolutional biology.

The dissertation offers, to a certain degree, an answer to the question “why L2 learners make errors,” and suggests successful development of learning English strategies to everyone who is interested in and struggles to learn English.

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Appendix A

Questionnaire for the JLE groups

(Directions written in Japanese)

言語及び実験についての質問

名前 : 性別 : 男・女 年齢 :

＊該当する番号に○を付けて下さい。また、（　）がある場合は（　）の中にも記入をお願いします。

I. 英語を学び始めたのはいつですか？

1. 中学 1 年生
2. 中学 1 年生より前 （ 歳から）
3. 中学 1 年生より後 （ 歳から）

II. 海外生活経験はありますか？

1. ない
2. ある （国名 : ）
（期間 : 年 ヶ月）
（年齢 : 歳 ヶ月から 歳 ヶ月）
（目的 :

III. 大学では、どのような英語の授業を受講しましたか？または受講中ですか？科目名を書いて下さい。

（ ）

IV. 大学の授業以外で英語に接する機会を定期的に設けていますか？

1. ない
2. ある （該当する項目に○を付けて下さい。複数可）

テレビやラジオの英会話、英会話学校、サークル、通訳のアルバイト、

海外の雑誌、英語の塾講師や家庭教師、英字新聞、英語のウエブサイト

その他　（　　　　　　　　　　　　　　　　　　　　　　　　　　　　　）

V. あなたの英語能力はどのくらいだと思いますか？　該当する箇所に○をつけて下さい。

1. リスニング

├──┼──┼──┼──┤

高い（ネイティブレベル）　　　　　　　　低い（まったくできない）

2. リーディング

├──┼──┼──┼──┤

高い　　　　　　　　低い

3. スピーキング

├──┼──┼──┼──┤

高い　　　　　　　　低い

4. ライティング

├──┼──┼──┼──┤

高い　　　　　　　　低い

VI. 実用英語技能検定（英検）の級、TOEFL や TOEIC のスコアなど、現在の自分の英語力が分かっていたら教えてください。

（　　　　　　　　　　　　　　　　　　　　　　　　　　　　　　　　）

VII. 今回の実験で，分からない単語はありましたか？

1. ほとんど分からなかった。
2. 75 %程ほど分からなかった。
3. 50 %程ほど分からなかった。
4. 25%程ほど分からなかった。
5. ほとんど分かった。

＊ご協力ありがとうございました。

ラボ教育センターの方にお聞き致します。

I.　ラボ・パーティーの所属時期、所属期間を教えてください。

才　から　　　　　　　年間

II.　ラボ・パーティー（英語活動）には週に何回、計何時間通っていますか？またはいましたか？

週　　　　　回　　　　　　　　計　　　　　時間

その他の活動：

III.　ご自宅では毎日どのくらい英語を聞いていましたか？

＊ご協力ありがとうございました。

(English translation of the questionnaire)

Questions about Language and the Experiment

Name:　　　　　　　　　Sex:　Male・Female　　age:

＊Please circle the number you feel is the most appropriate. Please also answer the question in (　) if the number has (　).

I.　When did you start to study English?

1. When you entered junior high school
2. Before seventh grade　(　　　year(s) old)
3. After seventh grade　(　　　year(s) old）

II.　Have you ever been abroad?

1. No
2. Yes　(country:　　　　　　　　)

(terms:　　　year(s) and　　　month(s))

(age: from　year(s) and　　month(s) to　　year(s) and　month(s))

(purpose:)

III. What kinds of English classes did you take? Or what kinds of English classes are you taking now? Please list the names. ( )

IV. Do you have regular chances that to be exposed to English outside classes in your school?

1. No
2. Yes (Please circle appropriate items. You can circle more than one item.)

   TV or radio programs on English conversation, English conversation school, English circle, Translator, English magazines, English teacher or private teacher, English newspaper, English websites,

   Others （ ）

V. How do you rate your English proficiency? Please draw ○ in one position you feel is the most appropriate.

1. Listening

High (Native-like) Low (not at all)

2. Reading

High Low

3. Speaking

High Low

4. Writing

High Low

VI. Please write down your current English proficiency level, such as the grade on the *EIKEN*, or *TOEFL* and/or *TOEFL* score.

( )

VII. How well did you understand the words in the experiment?

1. hardly understood the words.
2. could not understand about 75 percent of the words.
3. could not understand about half of the words.
4. could not understand about 25 percent of the words.
5. understood almost all the words.

＊Thank you very much for your cooperation.

For a member of the Lab Party

I. When did you join to the Lab Party, and how long have (had) you been a member in the group?

From year(s) For year(s)

II. How many times and how many hours in total do (did) you participate in English activity of the group in a week?

time(s) in a week hour(s) in total

The other activities:

III. How many hours do (did) you concentrate in listening to English CDs which you use(d) in the group at home?

＊Thank you very much for your cooperation.

Appendix B

Stimuli

The italicized word provides a critical word for the contrast between grammatical and ungrammatical, and an asterisk indicates that the word is ungrammatically used.

Case condition (a)

1. Every morning, the strange noise wakes *me*/**I* up.
2. My aunt bought *me*/**I* a new game.
3. My big sister made *me*/**I* a banana cake.
4. Every night, my mother read *me*/**I* a folk story.
5. The boy kindly lent *me*/**I* his bicycle.
6. My parents want *me*/**I* to be a piano player.
7. Last month, my American friend wrote *me*/**I* a letter.
8. Last night, my mother held *me*/**I* by the arm.
9. My uncle gave *me*/**I* a nice watch.
10. My grandmother raised *me*/**I* in Tokyo.
11. The old man hired *him*/**he* as a driver.
12. The boss picked *him*/**he* up to do the job.
13. I always contact *him*/**he* by e-mail.
14. Last week, the scientist sent *him*/**he* an important letter.
15. Everyone thanked *him*/**he* for his kind advice.
16. Many children love *him*/**he* very much.
17. The police officer let *him*/**he* stand there.
18. The lady passed *him*/**he* the salt.
19. The teacher watched *him*/**he* very carefully.
20. His parents sometimes visit *him*/**he* in Tokyo.

21. My father brought *us*/**we* some drinks.
22. My mother left *us*/**we* in the house.
23. My friend kindly got *us*/**we* tickets for the concert.
24. The officer introduced *us*/**we* to his boss.
25. The bus takes *us*/**we* to the station.
26. The pictures inspire *us*/**we* very much.
27. Every Sunday, farmers sell *us*/**we* good fruit at the market.
28. Yesterday, a very strong storm hit *us*/**we* in Japan.
29. Last Sunday, the bad news worried *us*/**we* very much.
30. The man kindly excused *us*/**we* for coming late.

Case condition (b)

1. I am sorry that *I*/**me* have no money with me today.
2. My mother said that *I*/**me* needed to eat breakfast faster.
3. My teacher told me that *I*/**me* had passed the very difficult test.
4. I am afraid that *I*/**me* lost my watch in school.
5. The girls said that *I*/**me* looked very much like my mother.
6. The woman believes that *I*/**me* am younger than my sister.
7. I was glad that *I*/**me* got an e-mail about my new job.
8. I think that *I*/**me* want to be a space scientist.
9. My friends know that *I*/**me* am very good at computers.
10. No one believes that *I*/**me* am under thirty years old.
11. I hear that *he*/**him* is a very bright man.
12. We know that *he*/**him* plays the drums very well.
13. I was glad that *he*/**him* got the first prize at the race.
14. I hear that *he*/**him* is very popular in Korea.
15. Everyone thinks that *he*/**him* is a good person for the job.

16. I noticed that *he*/**him* played an important role in the play.
17. We feel that *he*/**him* is a very nice boy.
18. Everybody thinks that *he*/**him* is over twenty years old.
19. I remember that *he*/**him* showed us an interesting magic.
20. My mother told me that *he*/**him* came to see me at the hospital.
21. We are sorry that *we*/**us* are late for the meeting.
22. I remember that *we*/**us* liked the same boy.
23. We found that *we*/**us* needed to clean the room.
24. I found that *we*/**us* made the wrong turn at that building.
25. People believe that *we*/**us* are leaders for the next generation.
26. I found that *we*/**us* needed one more week to finish the job.
27. We know that *we*/**us* both like watching football games.
28. We remember that *we*/**us* had a great time at the wedding ceremony.
29. We hear that *we*/**us* are next group to appear on the stage.
30. We noticed that *we*/**us* were already in the other city.

Present condition (a)

1. Many boys *like*/**likes* movies with action.
2. Lots of boys *climb*/**climbs* the tall tree.
3. Every day, several boys *play*/**plays* soccer after school.
4. Every year, ninety students *pass*/**passes* the entrance test for this college.
5. My two sisters *talk*/**talks* too much.
6. Many shops *close*/**closes* at 6 in the evening in this town.
7. Many foreigners *hope*/**hopes* to visit Kyoto.
8. Every month, two new girls *join*/**joins* the cooking club.
9. The two boys *look*/**looks* very happy.
10. Many interesting animals *live*/**lives* on the island.

11. Most stores *open*/**opens* at 9 o'clock on this street.
12. Some movie stars *print*/**prints* their names on this wall.
13. Many things *change*/**changes* in the city.
14. Sometimes, the three foreigners *perform*/**performs* Kyogen at parties.
15. Sometimes, my two brothers *laugh*/**laughs* at me so much.
16. Some boys *shout*/**shouts* into the big hole.
17. Some students *solve*/**solves* the math problems in that way.
18. Many cars *cross*/**crosses* the Golden Gate Bridge.
19. Many airplanes *land*/**lands* on this small island.
20. Lots of volunteers *support*/**supports* people in that hospital.
21. Every spring, my two brothers *paint*/**paints* their room.
22. Sometimes, some ships *disappear*/**disappears* in the sea.
23. My two dogs *bark*/**barks* at people passing by.
24. Most students *trust*/**trusts* the teachers very much.
25. Many Japanese ladies *watch*/**watches* Korean dramas on TV.
26. Many countries *promise*/**promises* to work for world peace.
27. Some cakes *taste*/**tastes* bad in this store.
28. Some students *use*/**uses* a computer in school.
29. Many Japanese students *stay*/**stays* in Canada.
30. Many classes *start*/**starts* at 8 in the morning.

Present condition (b)

1. Every evening, the little sisters *help*/**helps* their mother.
2. Every night, my dogs *want*/**wants* to go out.
3. The kids *believe*/**believes* the mysterious story.
4. The famous musicians *appear*/**appears* on the stage.
5. Every Sunday, my brothers *hunt*/**hunts* birds in the mountains.

6. Sometimes, my parents *invite*/**invites* many neighbors for dinner.
7. My cousins *work*/**works* on this farm.
8. The boys *show*/**shows* us how to use the computers.
9. The fantastic songs *move*/**moves* many people.
10. The sisters *train*/**trains* the dog very well.
11. The foreigners *recite*/**recites* the famous Japanese poem.
12. The farmers *produce*/**produces* very sweet watermelons.
13. The nurses *care*/**cares* for the old man.
14. Every spring, my sisters *fill*/**fills* a garden with beautiful flowers.
15. My brothers *share*/**shares* the big room.
16. The daughters *cook*/**cooks* dinner for their family.
17. Every month, the teachers *celebrate*/**celebrates* children's birthdays in the kindergarten.
18. My sons *ask*/**asks* me many questions.
19. The textbooks *include*/**includes* many good math examples.
20. The Beatles' songs *inspire*/**inspires* people around the world.
21. The astronauts *wait*/**waits* for contact from the earth.
22. The TV programs *increase*/**increases* interest in environmental issues.
23. The kids *need*/**needs* a sleeping bag for the trip.
24. The great songs *charm*/**charms* the audience.
25. Every morning, the small flowers *smell*/**smells* very sweet.
26. Our parents *enjoy*/**enjoys* telling us interesting stories.
27. Every Monday, the ladies *learn*/**learns* how to make a cake.
28. The bird's songs *sound*/**sounds* very nice.
29. The babies *smile*/**smiles* at their father.
30. The scientists *save*/**saves* the data in this CD.

Past condition (a)

1. In those days, many boys *liked*/**like* movies with action.
2. In the past, lots of boys *climbed*/**climb* the tall tree.
3. Yesterday, several boys *played*/**play* soccer after school.
4. Last year, ninety students *passed*/**pass* the entrance test for this college.
5. This morning, my two sisters *talked*/**talk* too much.
6. Ten years ago, many shops *closed*/**close* at 6 in the evening in this town.
7. Last year, many foreigners *hoped*/**hope* to visit Kyoto.
8. A month ago, two new girls *joined*/**join* the cooking club.
9. At last, the two boys *looked*/**look* very happy.
10. In the old days, many interesting animals *lived*/**live* on the island.
11. Last Sunday, most stores *opened*/**open* at 9 o'clock on this street.
12. After the last party, some movie stars *printed*/**print* their names on this wall.
13. After WWII, many things *changed*/**change* in the city.
14. A few years ago, the three foreigners *performed*/**perform* Kyogen at parties.
15. The other day, my two brothers *laughed*/**laugh* at me so much.
16. In the old days, some boys *shouted*/**shout* into the big hole.
17. Last time, some students *solved*/**solve* the math problems in that way.
18. Last weekend, many cars *crossed*/**cross* the Golden Gate Bridge.
19. Last vacation season, many airplanes *landed*/**land* on this small island.
20. After the last earthquake, lots of volunteers *supported*/**support* people in that hospital.
21. Last Sunday, my two brothers *painted*/**paint* their room.
22. A few years ago, some ships *disappeared*/**disappear* in the sea.
23. A few minutes ago, my two dogs *barked*/**bark* at people passing by.
24. At that time, most students *trusted*/**trust* the teachers very much.
25. Last winter, many Japanese ladies *watched*/**watch* Korean dramas on TV.

26. After WWII, many countries *promised*/**promise* to work for world peace.
27. In the past, some cakes *tasted*/**taste* bad in this store.
28. Ten years ago, some students *used*/**use* a computer in school.
29. Last summer vacation, many Japanese students *stayed*/**stay* in Canada.
30. In those days, many classes *started*/**start* at 8 in the morning.

Past condition (b)

1. Last night, the little sisters *helped*/**help* their mother.
2. Yesterday evening, my dogs *wanted*/**want* to go out.
3. At that time, the kids *believed*/**believe* the mysterious story.
4. At the last concert, the famous musicians *appeared*/**appear* on the stage.
5. Last fall, my brothers *hunted*/**hunt* birds in the mountains.
6. Last Saturday night, my parents *invited*/**invite* many neighbors for dinner.
7. Last summer, my cousins *worked*/**work* on this farm.
8. Last month, the boys *showed*/**show* us how to use the computers.
9. At the last concert, the fantastic songs *moved*/**move* many people very much.
10. Last weekend, the sisters *trained*/**train* the dog very well.
11. At the last party, the foreigners *recited*/**recite* the famous Japanese poem.
12. Last summer, the farmers *produced*/**produce* very sweet watermelons.
13. Last evening, the nurses *cared*/**care* for the old man.
14. Last spring, my sisters *filled*/**fill* a garden with beautiful flowers.
15. Ten years ago, my brothers *shared*/**share* the big room.
16. Yesterday, the daughters *cooked*/**cook* dinner for their family.
17. Last month, the teachers *celebrated*/**celebrate* children’s birthdays in the kindergarten.
18. Last night, my sons *asked*/**ask* me many questions.
19. In those days, the textbooks *included*/**include* many good math examples.

20. In the last century, *The Beatles*' songs *inspired*/**inspire* people around the world.

21. Before the last landing, the astronauts *waited*/**wait* for contact from the earth.

22. A few months ago, the TV programs *increased*/**increase* interest in environmental issues.

23. On the last trip, the kids *needed*/**need* a sleeping bag for the trip.

24. The other day, the great songs *charmed*/**charm* the audience.

25. Last spring, the small flowers *smelled*/**smell* very sweet.

26. Yesterday, our parents *enjoyed*/**enjoy* telling us interesting stories.

27. Last week, the ladies *learned*/**learn* how to make a cake.

28. This morning, the bird's songs *sounded*/**sound* very nice.

29. At last, the babies *smiled*/**smile* at their father.

30. Last time, the scientists *saved*/**save* the data in this CD.

Appendix C

Questionnaire for the ENS group

Questions about Your Language and Travel Experience

Name: Sex: Male・Female age:

I. Which country are you from?

Country: State:

II. How old were you when you came to Japan? How long have you been in Japan?

age: year(s) and month(s) terms: year(s) and month(s)

III. What is the purpose of your stay in Japan?

purpose:

IV. Have you ever been abroad except Japan?

1. No
2. Yes (country: ）

(terms: year(s) and month(s))

(age: from year(s) and month(s) to year(s) and month(s))

(purpose:)

V. Can you use any foreign languages other than English and Japanese?

1. No
2. Yes (language(s):)

(Please circle appropriate number. You can circle more than one item.）

(1) Can communicate in the language

(2) Can understand what is written in the language

(3) Can understand what people say in the language.

(4) Can write a diary in the language.

＊Thank you very much for your cooperation.